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GEORGE WILLIAM HILL.

F. R. MOULTON.

With the death of Dr. George William Hill, on April 16, 1914, this country lost one of its most eminent men of science. For nearly forty years he was regarded by competent judges, both in Europe and in America, as one of the few great masters of Celestial Mechanics. Academies and scientific societies had honored him with medals and universities had granted him their degrees. Men of the greatest reputation, such as Poincaré and Darwin, had confessed their indebtedness to him.

Dr. Hill was a scientific man of the old school. He was retiring and modest to the verge of timidity. He was absorbed in his own work but never inflicted it on others. In fact, he would hardly discuss it when others desired him to do so. He never made himself prominent at meetings of scientific societies, and never appeared in the popular magazines. He seemed altogether indifferent to his reputation with all except a few high authorities, and he knew he did not need to give any thought regarding his reputation with them. As he never married, he had neither the satisfaction nor the distraction which a family brings. He was, in short, a man of exceptional abilities who found keen pleasure in devoting a long and serene life to the pursuit of science.

Dr. Hill, of English-Huguenot descent, was born in New York City on March 3, 1838. Consequently he was more than seventy-six years of age at the time of his death. He graduated from Rutgers College in 1859 at the age of twenty-one years. While Rutgers College is not one of the more prominent American institutions of learning, it then had on its faculty a scholarly man, Dr. Theodore Strong, who exercised an important influence on Hill's life.* In some brief autobiographical

* For these facts I am indebted to an excellent biographical sketch of Dr. Hill published in the *Astronomical Journal*, No. 668, by President Robert S. Woodward, who was long his acquaintance and friend.

notes Hill said: „"Having shown some aptitude for mathematics it was decided to send me to college; and, in October, 1855, I took up residence at Rutgers College, New Brunswick, N. J. Here I found Dr. Theodore Strong, professor of mathematics, who was a friend of Dr. Nathaniel Bowditch, the translater of Laplace's *Mécanique Céleste.* I remember seeing in Dr. Strong's library the presentation copy of this work. Under his guidance, I read such books as LaCroix, *Traité du Calcul Différential et Intégral;* Poisson, *Traité de Mécanique;* Pontécoulant, *Théorie Analytique du Système du Monde;* Laplace, *Mécanique Céleste;* Lagrange, *Mécanique Analytique;* Legendre, *Fonctions Elliptiques.* My professor was an old fashioned man; he liked to go back to Leonard Euler for all his theorems; as he said, 'Euler is our great master'. He scarcely had a book in his library published later than 1840."

In this brief sketch of Hill's college work there is a wealth of material for reflection. In the first place, it shows what fine and unobtrusive scholars are sometimes found in relatively obscure places, and how great their influence may be on budding genius. Note how Dr. Strong guided Hill into reading the works of the masters. How many of us who have attended small colleges have had a course which could at all compare with that taken by Hill? Or, how many who now are taking work in our leading institutions are directed to so good sources of information and inspiration? It is not to be supposed that all students at Rutgers College in Hill's day read Poisson, Lagrange and the others; but this one example proves that Dr. Strong was a scholar and that he recognized unusual ability. His high estimate of Euler, who is universally regarded by competent judges as one of the greatest mathematicians who ever lived, proves that he had an instinct for what is really good. And this leads me to say that the best way to master a subject is to go to the highest sources, though no one would now limit his library to books published before 1840. In some way the real creators of a subject put into their work a certain life and inspiration that are never obtained by commentators.

In the second place, Hill's autobiographical notes prove that, even as a boy, he had exceptional mathematical ability. There are but few undergraduates in any institution who would voluntarily read such authors as Poisson, Lagrange, and Laplace. But to those who have the taste for such things the elegant writings of Lagrange are poetry and the dazzling mathematical operations of Laplace are a never ceasing source of wonder. There can be no doubt that Hill was greatly benefited by going so largely to original sources. He was naturally independent, and his contact with great independent minds cultivated this talent. Euler, Lagrange, and Laplace were not men who, travelling in beaten paths, simply went a little farther than their predecessors; they were

men who viewed the distant goal from the heights and made their own roads to it. And Hill was a remarkable man in the same way. The strongest impression I got when I began to read his work was that here, too, was an absolutely independent spirit. He gave new points of view and new methods of attack to almost everything he touched.

Shortly after graduation from college Hill was given a position in the Nautical Almanac office, then at Cambridge, Mass., but removed to Washington in 1867. He remained at this work until he reached the retiring age. He faithfully performed the routine duties incident to his position, but for more than thirty years he spent his leisure hours on the more difficult parts of Celestial Mechanics. Hill and Newcomb placed American mathematical astronomy on the same high plane that observational astronomy has always occupied in this country. In 1905-1907 Hill's Collected Mathematical Works were published by the Carnegie Institution of Washington in four quarto volumes containing together 1735 pages, and one volume of the researches which he has made since the earlier ones were printed remains to be issued. Hill is another of the splendid examples Astronomy has so many times offered of men whose intellectual activity has continued almost without decline to the end of their lives.

Hill's work included nearly every branch of Celestial Mechanics, and obviously it is impossible to give any adequate idea of all of it. Consequently I shall limit myself largely to his researches on the lunar theory, which contain the most splendid examples of his originality and rare powers of invention. Moreover, this is the work which gave him his greatest reputation and which he himself considered as his most important contribution to science.

Every one knows that one of the most famous problems in mathematical astronomy is the Problem of Three Bodies. The motion of the moon around the earth as disturbed by the sun is a special but very important case of this problem. Its discussion started with Newton, in 1686, and now after a lapse of over two hundred years and the work of a great number of mathematicians it can not be regarded as completely solved, both from the practical and the logical point of view. In the discussion of this problem there are four principal epochs, the fourth of which is due to the work of Hill.

One of the applications of the law of gravitation, made by Newton, was to the explanation of the motion of the moon. It had long been known that there is a regression of the nodes of the moon's orbit, an advance of the perigee, a periodic perturbation known as "the variation", another still larger one called "the evection", and numerous smaller irregularities. If the law of gravitation is true it will not only explain the conic section motion of the planets, but also the deviations from

the elliptic motion of the moon due to the perturbing action of the sun.

Newton recognized the fact that the motion of the moon gave a critical test of the law of gravitation. He also recognized its great difficulties. But this did not deter him from attempting to solve the problem of determining the effects of the attraction of the sun. In Section XI, Book I, of the *Principia* he gave a masterly analysis of the problem in what Sir George Airy said was "the most valuable chapter that was ever written on physical science."

The method of Newton was to regard the moon's orbit as an ellipse, but one which is continually changing. It is easy to see that, since if at any time the sun's attraction were henceforth to cease to act the moon would from that instant move in a fixed ellipse about the earth, the actual motion may be regarded as taking place in an ellipse whose elements vary constantly. Newton by a very skilful use of geometrical considerations and numerical approximations obtained a good first approximation to the way in which the elements vary. It should be noted, however, that his results, as published in the *Principia*, were much in error for the motion of the perigee; but in unpublished papers first brought to light in 1872 this discussion was supplemented by another which gave nearly the true value.

The second period in the lunar theory is that following Newton when continental mathematicians, and particularly the French, took up the task of applying the more powerful methods of analysis instead of the special geometrical ones which the English still used. It reaches from the work of Clairaut, d'Alembert, and Euler, beginning about 1745, down to that of Delaunay about one hundred years later. To this period belongs the work of Laplace, Poisson, Plana, Lubbock, de Pontécoulant, and others. It is not to be inferred that there were not differences in the treatments of these various writers. To all external appearances the various theories were quite distinct. But the fundamental point of view of all was the same, the differences consisting largely in the choice of variables and parameters and the modes of procedure in obtaining the coefficients.

The third period in the history of the lunar theory is that due to the work of Delaunay which was published in 1860. He carried to its logical end the process of considering the elements of the moon's orbit as varying. Suppose the undisturbed elliptic orbit of the moon is caused to vary by the attraction of the sun. The solution will depend upon certain constants, equal in number to the elements of the orbit, which specify how the elements are varying. But if the moon departs from its elliptic orbit by the variations just considered the disturbing force of the sun is changed, and it is necessary to cause to vary the constants which were introduced at the first stage of the solution.

These deviations are specified by a new set of constants which give rise to a new set of disturbing forces, and so on in an unending series. Delaunay developed a systematic process for varying first the elements, and then the equivalent constants at successive steps, and carried out the details to an extent never before approached. The development of the final literal series for the three coördinates of the moon took twenty years, and several hundred quarto pages were required to print them. The death of Delaunay terminated his work before he succeeded in reducing his series to numbers. The method he used is one of great elegance which Hill especially has shown is conveniently applicable to many other problems.

The fourth period in the history of the lunar theory dates from Hill's publication, in 1877, of his memoir "On the Part of the Motion of the Lunar Perigee which is a Function of the Mean Motions of the Sun and Moon." This paper was republished in *Acta Mathematica*, Vol. VIII (1886). But it is logically preceded by the memoirs which were published in 1878 in Vol. I of the *American Journal of Mathematics*.

Let us first consider the memoirs published by Hill in the *American Journal of Mathematics*. In the introduction he explains how he is dividing up the problem, and at this time he intended to give it a complete treatment, for he said: "A general method will also be given by which these investigations may be extended so as to cover the whole ground of the lunar theory. My methods have the advantage, which is not possessed by Delaunay's that they adapt themselves equally to a special numerical computation of the coefficients, or to a general literal development. The application of both procedures will be given in each of the just mentioned five classes of inequalities, so that it will be possible to compare them." As a matter of fact, Hill treated only the first two of the five divisions of the subject.

In the papers published by Hill in the *American Journal of Mathematics* there is introduced for the first time a very radical and important idea. Up to this time the orbits of the moon and planets were considered as being ellipses which continually change. The problem was to find the changes in the ellipses, or the deviations from the initial ellipses. That is, the ellipse was taken as a first approximation to the orbit of the body under consideration. Hill proposed to take a certain simple type of periodic orbit as a first approximation. He proved the existence of the periodic orbits by numerically integrating the differential equations in numerous special cases by a process known as mechanical quadratures. These were the first periodic orbits of the problem of three bodies having a practical use, and the first ones known to exist beyond the simple ones which were discovered by Lagrange. It should be added that Hill omitted a small part of the disturbing

action of the sun, viz., that which is said to depend upon the solar parallax; but his method would have applied without sensible modification to the rigorous problem. In fact, in all his researches on the problem of three bodies, Darwin used methods which differ from those of Hill only in the variables employed and in inconsequential details.

Having proved by computation the existence of periodic orbits, the problem was to devise mathematical expressions for representing them. This Hill did with extraordinary skill and elegance. As he stated, his methods were adapted either to a literal or to a numerical treatment. He carried them out in both ways. I once heard a prominent astronomer say what seems to be a common impression among astronomers, viz., that Hill's work was purely theoretical. Nothing could be farther from the truth. No earlier work had approached it in practical applicability, and no subsequent work has surpassed it. For example, he gave the coefficients of the periodic orbit which was to serve as a first approximation to the orbit of the moon to fifteen decimals, and worked out all terms which were sensible with this degree of accuracy.

There is a single flaw in this part of Hill's work, and that is that he did not prove the convergence of the series he employed. He was not blind to this defect for he wrote: "I regret that, on account of the difficulty of the subject and the length of the investigation it seems to require, I have been obliged to pass over the important questions of the limits between which the series are convergent, and of the determination of superior limits to the errors committed in stopping short at definite points. There cannot be a reasonable doubt that, in all cases, where we are compelled to employ infinite series in the solution of a problem, analysis is capable of being perfected to the point of showing us within what limits our solution is legitimate, and also of giving us a limit which its errors cannot surpass. When the coördinates are developed in ascending powers of the time, or in ascending powers of a parameter attached as a multiplier to the disturbing forces, certain investigations of Cauchy afford us the means of replying to these questions. But when, for powers of the time, are substituted circular functions of it, and the coefficients of these are expanded in powers and products of certain parameters produced from the combination of the masses with certain of the arbitrary constants introduced by integration, it does not appear that anything in the writings of Cauchy will help us to the conditions of convergence."

This was a remarkable statement to have been written in this country in 1878. It shows a clear understanding of all that was known at the time of the subject of the convergence of solutions of differential equations in series. Hill had a point of view and familiarity with the literature altogether beyond any other astronomer in this country, and it is

questionable if he was then surpassed by any mathematician. Since Hill's work there have been few attempts at proving the convergence of the series used in the lunar theory, and no real progress in the matter has been made. For the most part the question has been entirely ignored. Yet, as Hill indicated, the lack is a real defect, and mathematicians will not abandon the subject until it is fully remedied; for, if the series are not known to converge, what seems to be a solution of the problem may be an illusion. It should be remarked that the series appear to converge rapidly, they do converge (as I have proved) for a moon whose period is not too great, and there is nothing to make us suspect they do not converge for our satellite. The problem is one of great difficulty, and there is no hope whatever of solving it except by the use of such powerful methods as those Cauchy introduced in his theory of functions of a complex variable.

Hill wrote a number of later articles, published in the *Astronomical Journal*, on periodic orbits. They are all of a high order of merit, but in spirit and method do not surpass his original work, and they show no influence of the epoch-making researches of Poincaré. On the whole they are of a practical character, and one was for the purpose of developing a theory for the orbit of Saturn's satellite Hyperion.

Hill's memoir in *Acta Mathematica* is generally regarded as his most brilliant work. He so regarded it himself. The purpose of the paper was, supposing that at a given instant the coördinates and components of the moon's velocity in the plane of the ecliptic differ slightly from what they would be in the periodic orbit which he had found, to find the character of the deviations about the periodic orbit. It is not at once clear how this is attached to the lunar perigee and to the eccentricity of the moon's orbit. As a matter of fact, there is no eccentricity to the moon's orbit in the ordinary sense, and writers have differed as to what they have called its eccentricity. But there is a real physical idea involved, and in Hill's work it comes out in an altogether new way.

In discussing the deviations from the periodic orbit Hill was led to a fourth order system of linear differential equations having periodic coefficients. The solutions of such equations had never been treated. By means of the energy integral he reduced the system of equations to a single equation of the second order. He then inferred the character of the solution by analogy with a corresponding differential equation having constant coefficients, and from previous work on the lunar theory. The solution involved an unknown exponent c, which was to be determined, and the coefficients of an infinite number of terms. When the series with undetermined coefficients were substituted in the differential equation the condition that it should be satisfied led to an infinite series of linear homogeneous equations, each involving an

infinite number of the unknown coefficients. The coefficients of these equations involved the unknown exponent c. If the number of equations is finite and the number of unknowns which occur linearly and homogeneously is equal to the number of equations, the condition that there may be a solution which is not zero is that the determinant of the coefficients shall be zero. Is the same thing true for an infinite system? Hill assumed it is true and thus introduced the infinite determinant. Each of its lines involved c. Hence it might be expected that the equation would be satisfied by infinitely many values of c. Such is the case, but the various values are simply related to a certan principal value. Hill found these relations by a course of brilliant reasoning and showed how to get the principal value. In discussing this determinant he made his loftiest flight. Moreover, he carried out the whole work numerically (and later literally) and gave the rate of motion of the moon's perigee so far as it depends upon the first power of the eccentricity of the moon's orbit to fifteen decimals, an accuracy never before approached and fully sufficient for all purposes.

Hill's work on the motion of the lunar perigee has been of great importance. It introduced into mathematics infinite systems of linear equations, a subject which is just now being cultivated by some of the most eminent mathematicians in the world. It called attention to the infinite determinant which has been the subject of memoirs by von Koch and Poincaré. The methods of Hill were used by Darwin without essential modification in determining the character of the stability of the periodic orbits which he discovered. In insisting that Darwin used the methods of Hill both in discovering periodic orbits and in examining their stability, it is not my purpose to take from him any of the large amount of credit which is his due for the enormous amount of work that he did; but it is desired to point out that in all essential respects Hill was the pioneer.

The question naturally arises why Hill did not complete his lunar theory according to his announced intention and plans as set forth in his first paper on the subject. The question had often arisen in my mind. After one of the meetings of the National Academy in Washington a few years ago Hill asked me to take a walk with him. It was one of the splendid afternoons that are often found in Washington in late April. The bright green vegetation and newly-opened flowers were particularly beautiful to us because they were still held back by the cold winds which at that time of the year were sweeping across the northern states. Hill laid our course down one of the beautiful avenues for which Washington is noted and out toward the country. Soon the invigorating air and the glow from the exercise put us in the best of spirits. I then

asked him to give me some account of his work on the lunar theory. With the utmost modesty, yet with considerable freedom, he told me about it.

At the time Hill was publishing his papers on the lunar theory Simon Newcomb was in charge of the American Ephemeris and Nautical Almanac office in Washington, and he had the worthy ambition to get out new tables for the motions of the planets which should surpass all those in existence. The most troublesome problem in this program was the determination of the mutual perturbations of Jupiter and Saturn. Newcomb recognized Hill's ability and assigned him the task of developing the theory of the motion of these planets. The result of this assignment is comprised in the 577 pages of Volume III of Hill's Collected Works, and required seven and and one-half years of steady computation for its completion. Hill told me that he thought the greatest piece of astronomical calculation ever carried out by one man was Delaunay's lunar theory, and that his work on Jupiter and Saturn came second. Now the greater part of this work was straight computation by methods which were largely due to Hansen, and which could have been carried out under Hill's direction by men who did not have his great ability for original work. It seems probable that science lost much because Newcomb caused Hill to spend about eight years of the prime of life on this work. At any rate, this was the direct cause of his laying aside, as he thought for a time only, his researches on the lunar theory. In the mean time E. W. Brown, who had graduated at Cambridge, England, and had attracted the very favorable attention of Darwin, became interested in the lunar theory and recognized the great superiority of Hill's methods. In his first paper, published in the *American Journal of Mathematics* in 1892, he treated the fifth of the divisions into which Hill had separated the problem; and the methods he employed were so exactly those of Hill that Hill could not have treated the question without duplicating the work. However, it is not to be understood that this was done without Hill's consent; it simply explains why Hill never wrote on this phase of the subject.

A little later Brown took up the problem of developing a lunar theory on the general basis that Hill had laid down. While Hill had conquered the most important difficulties, many still remained and the task was one requiring enormous labor. The problem has been entirely completed by Brown in the most satisfactory manner. While his work is above criticism we can not but regret that we have not also the treatment of the subject that Hill might have given. In this connection I may translate from Poincaré's introduction to the first volume of Hill's Collected Works a few sentences: "It is on these (Hill's) principles that the new theory of Brown has been founded. This theory is

much more perfect than all others hitherto known, and there are grounds for the hope that it will permit us to push the approximation much farther than it has been carried by Hansen and Delaunay. It would be unjust not to recognize the personal part that Brown has taken in this great work, and the originality of the ideas that he himself has brought to it. But it would be more unjust still to forget that it is Hill who has laid down the principles; that he has vanquished the first difficulties and that these difficulties were the greatest ones." Poincaré also expressed the opinion that the methods of Hill were capable of quite other applications than to the theory of the moon. and he said, "When they are extended to a domain more vast, we must not forget that it is to Hill that we owe an instrument so precious."

SHOOTING STARS.

CHARLES NEVERS HOLMES.

As a rule, the appearance and disappearance of so-called "shooting stars"—the sudden flash and more or less rapid vanishing of such swiftly moving aerolites—are very uncertain. Indeed, there are few times in the year when one can be sure that a larger number of these "stars" will fall; and, as a rule, he will watch quite a while before a single spectral "star" comes and goes. There are, however, a few times when he may be fairly certain of a larger exhibition of "shooting stars". On some of the nights of April, August and November, there are, as a rule, more of such aerolites flashing across the darkened firmament, and, occasionally, once in every thirty-three years, for example, one may witness a remarkable display of "shooting stars."

As a rule, such "stars" seen throughout the night are few and scattered. Now and then, after perhaps a half-hour's watching, there will come a sudden flash—more or less bright—and it may be that another such flash will follow soon; but appearances of aerolites upon most clear nights are rather few and far between. But around April 19-22, August 9-11, November 12-14 and 27, there are very likely to be excellent exhibitions of "shooting stars." That is, on these dates, our little planet, revolving around the sun, enters or crosses certain regions more closely filled with aerolites. As a result, a larger number of these little particles are captured by the attraction of the earth and are destroyed by their friction with the terrestrial

atmosphere. On these dates, our world rushes through certain swarms of aerolites that are themselves in motion, in a motion so consistent that our planet passes annually at about the same time through these respective swarms. But, although our earth reaches and passes through these swarms of aerolites at stated times, and although the probability is that there will be seen a larger number of "shooting stars", the frequency and splendor of such a display are uncertain, depending upon whether our planet penetrates that part of the swarm which is most densely congested.

The collision of our earth with these stated swarms of aerolites is, of course, indicated to us by certain flashes in the darkened firmament, and these sudden flashes will appear in certain parts of the starry heavens according to which respective meteoric swarm is encountered. These parts or points of the firmament are called the "radiant points of meteors," and the displays given by these burning aerolites are also called "showers." There are four principal radiant points giving rise to such "showers." The first of these "showers"—the meteoric swarm of about April 19-22—is known as the "Lyrids", and is in the vicinity of the constellation Lyra where blazes the blue, brilliant sun Vega. The second of these—the meteoric swarm of August 9-11—is called the "Perseids", and is not far firmamentally from Eta of the constellation Perseus. The third of these meteoric "showers" is known as that of the "Leonids", occurring around November 12-14, and its "radiant point" is situated between the suns Gamma and Epsilon of Leo. The fourth and last is called the "Andromedids"—not far from the sun Gamma of the constellation of Andromeda. The "Andromedids" become active around November 27. All of these "showers" vary, of course, from year to year; those of the "Lyrids" in April being particularly uncertain, while the "Perseids" in August give perhaps the most consistent display.

But although the "Lyrids" and the "Perseids" are at times somewhat spectacular, the "Leonids" and the "Andromedids" are the most interesting of these four principal showers of "shooting stars". The "Leonids" are particularly interesting in the fact that for centuries they gave such spectacular displays, these displays occurring once about every thirty-three years. The first recorded exhibition was in the year 902 A. D., and there were remarkable displays of the "Leonids" in 1799, 1833 and 1866. However, the display of 1899-1900 was a great disappointment, and what the exhibition of 1933 will be cannot, of course, be foretold.

The suggestion has been made that the "Leonids" were captured and brought into our solar system by the planet Uranus somewhere around the year 126 A. D., and it has been calculated that this swarm of aerolites revolves rapidly around the sun in an oval orbit almost two billion

miles in length. However this may be, we are sure that every year our little earth encounters about November 12-14 some of the swarm of these "Leonids", and that the three times in a century—once about every thirty-three years—our planet should pass through a dense congestion of aerolites of the "Leonids".

But the showers of the so-called "Andromedids" are also very interesting, and the "Andromedids" give their best exhibition every thirteen years, instead of every thirty-three years. Of course, the "Andromedids" give an annual exhibition about November 27; and, of late years, it is difficult to predict what their next best display will be like. But our chief astronomical interest in the "Andromedids" is because of their supposed association with a former comet called "Biela's". This comet is a "lost" one, that is, it has not been observed for a long time. It was discovered in 1826 by an Austrian officer named Biela, its "period" being 6.6 years and its orbit coming at times close to our terrestrial one. In 1839, this small comet was not observed, but reappeared in 1846, when it was divided into two parts. In 1852 the divided comet was again seen; but from that time to this Biela's comet has been absent from its periodic place in the star-lit heavens.

Upon the night of November 27,1872, just as our planet was crossing the orbit of this lost comet, there occurred a splendid meteoric shower. Another meteoric shower happened in November, 1885, as our earth was once more crossing the former orbit of the comet, and the supposition naturally arose that the showers of 1872 and 1885 were due to the presence of Biela's lost or destroyed comet. Thus, the meteoric showers of November 27,[4] called the "Andromedids", have come to be associated with the former existence of Biela's comet, our earth happening to cross the track of the scattered particles of that lost comet on this date, and the presence of some of these particles being made known to us by their friction with the terrestrial atmosphere. As has been stated, the radiant point whence these "shooting stars" appear is not far from Gamma in the constellation of Andromeda—that is, the radiant point of the "Andromedids" is rather close firmamentally to the radiant point of the "Perseids."

The "Lyrids," "Perseids," "Leonids" and "Andromedids" constitute, therefore, the principal "shooting-star showers" of the darkened firmament, the "Leonids" and the "Andromedids" being the most interesting. But these sudden "shooting stars" appear and disappear at all hours of the night and at all seasons; and, indeed, are colliding with our atmosphere every hour of the day, although doubtless we miss seeing many splendid exibitions because of the bright light of our sun. Calculations have been made respecting the total number of "shooting stars," or, rather, of aerolites that are destroyed by friction with our atmosphere

every twenty-four hours, and this number has been published as approximately 16,000,000. Other estimates would probably vary more or less from this total of 16,000,000 aerolites captured and destroyed daily by our planet. The total number must, however, be very great, and bombardment of our world by these tiny or larger particles is going on continually. In other words, a constant rain of pieces of stone and iron—pieces weighing a few grains to those, occasionally, weighing tons—is pouring upon our protecting atmosphere. Sometimes just a single piece of stone or iron will bombard our earth; but more often separate fragments of a former larger single piece, these fragments being perhaps many thousands in number. In the case of so many fragments of a former single piece, these fragments would be rather small or even very tiny.

Various collections of aerolites that have successfully passed our protecting atmosphere and reached the terrestrial surface are to be found in various national and university museums, some of these intruding meteors being of considerable size. As would be expected, specimens of these surviving aerolites have been analyzed, and 24 of the chemical substances of our planet have been found in these meteors. But no new chemical elements have been discovered; the fallen aerolites are chiefly composed of stone or nearly pure iron more or less alloyed with nickel.

It has been estimated that when an aerolite becomes a burning "shooting star", its temperature is approximately 1000 times that of red heat. The result is that the aerolite burns rapidly and dissolves into dust. It has also been calculated that such aerolites strike our atmosphere with velocities that vary from 20 to 40 miles per second. Thus, most of these dangerous intruders burn up entirely before they can do any harm, presenting all sorts of firmamental fire and light to our terrestrial vision. Occasionally, however, one of them larger than the others passes entirely through the protecting atmosphere and violently strikes the ground. Of course it is greatly reduced in size by its atmospheric encounter, but such a solid shell from the skies is not an object that we of this earth wish to fall close to us.

Our little planet is, therefore, under continual bombardment from the universe immediately around it; but it is sheathed in armor that satisfactorily protects it. The flying, fiery aerolite-shells are indeed large and swift; but the soft, deep atmosphere swallows up and dissipates almost all the rocky particles hurled into it. Few of us ever see a meteor strike near at hand, the nearest we view the flight of an aerolite is as it dissolves in dust and fire high overhead. But we should indeed be thankful that our atmosphere stands as a protection between us and the constant bombardment of aerolites. It would certainly not be comfortable to feel that one was, as it were, "under fire" all the time.

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A CURIOUS VARIETY OF METEOR.

W. F. DENNING.

In *Monthly Notices* of the R.A.S. for June 1885 I wrote a short paper on a special class of meteors which I had occasionally observed. They exhibit exceedingly swift motion, give an impression of extraordinary nearness and show no heads, trains or streaks. In fact they are mere gleams of white or bluish-white light, seemingly quite close, and very dissimilar to the ordinary meteors which are probably what their appearances suggest, viz., solid bodies in a state of combustion and dissipation. The special kind, of great velocity, to which I have alluded is somewhat rare and perhaps I have not seen more than one or two in every 500 meteors of normal type and they certainly suggest electrical origin.

Were it not for the fact that in recent years several ladies in the United Kingdom have taken up observing meteors with an enthusiasm equal to their ability I am afraid that this branch of science would have made little progress here on its practical side. I mention this matter because two of the excellent observers referred to have succeeded in recording specimens of the rather exceptional phenomena sometimes seen here.

On March 19, 1914 Mrs. Fiammetta Wilson recorded two of them as "appearing quite near, moving terribly rapid and suggesting little lines of light rushing close to one like a lighted wire." Miss A. Grace Cook has also witnessed the flight of several similar objects, viz., on 1913 September 13, November 1 and December 1 and 1914 February 1. She remarks, "This class of meteors is so different and distinct from ordinary ones that they are unmistakable when seen. They give one a little shock of almost fear, certainly surprise, at their seeming nearness and tremendous rapidity. They show no heads and I never saw one with either a tail or an after-streak."

In late years I have not been able to pursue meteoric work to the same extent as formerly but I have occasionally caught one of these transient flashes. The last one seen here was on 1913 August 23 near the star Polaris and the meteor had a duration of less than the tenth of a second. It looked like a mere gleam of light; not a burning missile.

It is a noteworthy point that I have witnessed a few of these very rapid meteors directed from the western sky and from a region where we should expect the apparent motion to be very slow.

Colonel Tupman saw one of these rapid objects in 1870 January 9 and he says of it that though it had a path of 31° its duration was only 0.1 second. "An instantaneous flash seemed to be in the air, quite near."

There are many varieties of meteor visible in the heavens and it is very desirable that observations of curious objects should be fully recorded whenever they are seen.

Bristol, March 25, 1914.

THE COMPLETING OF AN ECLIPSE CYCLE.

F. E. SEAGRAVE.

As astronomers are so interested in the coming total solar eclipse of August 21 next, it may be of interest to know that before the end of the present century this cycle or family of eclipses will run out, or cease to produce total eclipses, the last total eclipse taking place on October 3, 1986, or the fourth return of the eclipse of next August. I have computed the track of central eclipse of all of the eclipses of this cycle up to the year 2004 (descending node eclipses) by the method of the late Professor Newcomb in his work "The Recurrence of Solar Eclipses."

At the next return of the eclipse of August 21, which will take place August 31, 1932, the shadow will first touch the earth in about longitude 130° 50′ west of Greenwich and latitude 84° 45′ north; will travel southeast across Hudson Bay and down over Canada, and the extreme northeast part of New England, leaving the earth in about longitude 43° 40′ west, and latitude 27° 56′ north. The next return will take place September 11, 1950. The track of central eclipse will be as indicated in the following table, the time in hours being referred to the instant of conjunction:

	Time	Longitude	Latitude
	h	° ′	° ′
	− .75	− 95 30	+87 12
	− .50	−152 36	+72 14
	− .25	−160 02	+63 20
Conjunction	.00	−165 03	+56 04
	+ .25	−169 33	+49 49
	+ .50	−174 25	+43 58
	+ .75	+179 17	+38 22
	+1.00	+167 57	+32 35

The next return will take place September 22, 1968. The shadow will in this eclipse touch the earth in about longitude 109° 10′ east latitude 79° 57′ north, and will leave the earth in latitude 41° 30′ north. In the eclipse of October 3, 1986, which will be the fourth return of the eclipse of next August, and the last total eclipse of the cycle, the shadow will travel almost due south as it will be pretty far north. The return of October 14, 2004 will be a partial eclipse only as the shadow will just graze the north pole.

I have looked into the matter very carefully to determine when the *first* total eclipse of this series took place. The first total eclipse took place on June 11, 1211. The first partial eclipse (just barely partial at the south pole) took place one hundred and ninety seven years previous to this date, which would make it in 1014. The central eclipse of this series took place February 14, 1608. The last partial eclipse, barely partial at the north pole, will occur in the year 2184.

There have been many fine eclipses of this family in modern times, among them The New England Eclipse of June 16, 1806. This was total in New York State, and in Vermont and New Hampshire. It was observed by the late Dr. Bowdich of Harvard College, but he hardly mentioned the corona or the prominences. He merely says, "the whole of the moon was then seen surrounded by a luminous appearance." The famous eclipse of July 8, 1842 belongs to this family, and Mrs. Todd in her book on Total Eclipses of the Sun says of it, "while the Eclipse of 1842 marks the dawn of a golden age of physical research upon the Sun, investigation proceeded slowly." This eclipse was observed by many eminent astronomers of that time. The prominences were observed visually and photographically. The eclipses of July 18, 1860, and July 29, 1878 both belong to this cycle.

The eclipse of July 29, 1878 was well observed by astronomers all along the line of totality. The moon's shadow entered the United States in Washington Territory and Oregon, traveled southeast over Wyoming, Yellowstone Park, Colorado, and into Texas; and left the earth in the Gulf of Mexico near the west Florida coast. The writer observed the eclipse at Fort Worth Texas, he being a member of a party of five. The other members were Dr. Leonard Waldo then of Harvard College Observatory, Professor Robert Willson of Harvard College, Professor J. K. Rees of St. Louis and Wm. H. Pulsifer of St. Louis. This eclipse was well observed by this party, visually and photographically. The writer (then nineteen years old) observed the reversion of the Fraunhofer lines at totality, and observed and measured position of the 1474 line. Excellent drawings and photographs were taken by different members of the party. This eclipse probably

attracted the attention of astronomers more than any other as the shadow traveled mostly over the land, and places along the central line were accessible.

The next eclipse was the one of August 9, 1896. This was visible mostly in northern Europe but if I remember correctly many of the observers were defeated by clouds and bad weather.

The eclipse of next August will be a most interesting one, especially so as we are now about at the end of a very long and drawn out period of sunspot minimum.

Boston, June 2, 1914.

MONTHLY REPORT ON MARS.—No. 6.

WILLIAM H. PICKERING.

Lunar Canals.

The present Report will be devoted chiefly to a study of the canals. By a canal in the astronomical sense of the word is meant any long narrow dark marking that is straight, or of large radius of curvature, and of fairly uniform breadth and density. The existence of the canals on Mars as objective realities must appear obvious to any one who has seen the planet under sufficiently favorable circumstances. They have been seen at this station with the 11-inch refractor by using a magnification of 660 when the diameter of the planet was but 5.″6. When well seen they can be held by the eye like any other real marking, for indefinite periods. The main cause of the controversy regarding them is that in northern latitudes, where most of the large telescopes are located, the seeing is not sufficiently good to show them well, and their existence therefore continues to be doubted in some quarters.

Another cause of doubt depends on the mistaken idea still held by the public, and also by many astronomers, that the larger the telescope the more you can see with it. If the seeing were good enough, or if the objects were very faint, this would obviously be true. But even with double stars there is a limiting size of aperture giving the best results, depending on the quality of the seeing, and with bright planetary detail this limit is very marked indeed. The statement once made in joke, that the 40-inch Yerkes lens is too powerful to show the canals of Mars, is literally true. There are too many air waves constantly passing in front of its great surface to permit of the necessary planetary definition.

For our north-eastern states the best results on a good night can be obtained with an 8-inch aperture. In the southwest 16 inches is perhaps the limit. The proper size for the tropics has not yet been reached by any instrument located there, and is still unknown. Any telescope intended for regular use on planetary detail should be provided with a cat's eye diaghragm placed over the objective, which can be adjusted instantly from the eye end of the telescope,—a device first used I believe at the Lowell Observatory.

As a means of studying the canals of Mars, it occurred to the writer that since the moon is a body closely resembling it, and of the same order of size, if we were to apply to it the same magnification in proportion to its distance, that we might get a similar effect. The average distance of Mars at opposition is fifty million miles. The average distance of the moon, one quarter of a million. The moon being at one-two hundredth the distance of Mars, we should use one-two hundredth the magnification, The Martian canals are well seen with a power of 500. An ordinary opera glass, giving a power of 2.5 would therefore be a proper instrument with which to view the moon. If we wish to have the moon appear of the same size as Mars, a field glass magnifying five times should be employed.

A preliminary sketch made with an opera glass on April 28, 1912 showed a number of long narrow canals crossing the face of the moon. Of these the most conspicuous was the broad double canal shown in Figure 1, extending north-westerly from Tycho. Next came the three canals to the west of it, and a few of those shown in Imbrium. All were narrow and quite uniform in appearance. The present sketch was made with a field glass magnifying four times, on October 14, 1913, colongitude 90°. The double canal extending from Tycho was now so broad that it had almost lost its canal like character, but numerous fine canals appeared, among them several exceeding 400 miles in length. Only the more conspicuous ones have been drawn, in order to avoid confusing the sketch. When near the terminator the canals are faint or invisible. They seem to be most conspicuous when the moon is full, and individually to vary more or less with the colongitude. It would seem as if a detailed study of them might repay the careful observer. Perhaps the best results are obtained on a slightly hazy evening, or with the moon not very far above the horizon, so it shall not be too dazzling. Even with an opera glass better results are obtained if it is steadied by holding it against a post. It is perhaps easier to see them in the first place with a field glass, but once seen, an opera glass gives them a more canal-like appearance. With the latter they are narrow straight and grey or black, with the former they show a slightly irregular structure, and are at times distinctly brownish. There

are few canals on Mars more distinct than those between Copernicus and Aristarchus when seen under favorable conditions with an opera glass.

But it is not necessary to wait for a moonlight evening in order to see the lunar canal. The same result can be obtained, though in an inferior way, from any good photograph of the full moon. This should be placed against the wall in a strong light, and viewed with the naked eye from a distance of between twenty and forty times its diameter. If we get nearer than this, we see that the lakes, with the exception of Plato, are not sharply defined regions, but simply small dark areas of irregular shape and density, which are in reality much larger than they appear in the drawing. Similarly the canals, which are drawn as heavy fine lines, are in reality broader and less intense areas of the same length. They vary in general from 20 to 60 miles in breadth. The effect is clearly not due to areas of irregularly distributed and imperfectly seen fine detail. The surface is not necessarily irregular in density, nor spotted, nor filled with any detail at all. All that is required to produce a canal is a comparatively slight difference in density, a reasonable breadth, and a sufficient intrinsic brilliancy to render it visible.

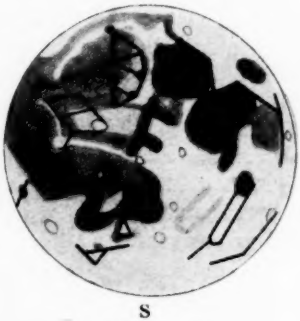


FIGURE 1.

FIGURE 2.

Some of the canals are produced in a different manner however. Thus the little canal near the limb south of Crisium, as far south as its junction with the canal from Tranquillitatis, is due to a line of intensely black variable spots filling the bottoms of craters, and persisting in their blackness almost until the time of sunset on that region. The canals bordering Serenitatis and Tranquillitatis are perhaps due in part to contrast between the dark and bright regions, but in part also to dark variable spots lying at the foot of the elevated regions bounding the *maria*. In this double origin they resemble the Martian canal Triton,

so well seen at the past opposition. It is instructive slowly to approach the photograph to within a couple of feet, and watch the changes,—especially in the regions of the double canals.

The writer cannot but feel that we have here an analogy, which may help us in explaining the so-called canals of Mars. That they have an objective reality is clear, but perhaps they are not the narrow, striking, artificial looking objects that our drawings represent them. Some of those that we see the best, like Sabaeus, Nilosyrtis, and Thoth, see Figure 2, are doubtless in reality very much as they are drawn, like the broad canal shown in the extreme north of Figure 1, which fairly represents the region when it is seen under a higher power. But it would appear that broad faint natural areas and narrow dark artificial ones present to the eye exactly the same appearance when viewed from a suitable distance, so unless we can increase our magnifying power sufficiently, there seems to be no way of distinguishing with certainty between them.

The three martian canals Sabaeus, Nilosyrtis, and Thoth can readily be identified by means of the map published in connection with the first Monthly Report. The first of these is not usually referred to as a canal, but it obviously differs little from the other two, and still less from Cerberus as it appeared at this opposition. It is conspicuous for a large portion of every martian year when sufficiently near us, but is at times invisible. Such was the case at this past opposition prior to November, that is, prior to longitude $\odot = 0°$. It is subject to considerable change in shape and is at times quite irregular; it is therefore possible that the others would be so also, could we see them sufficiently clearly. Nilosyrtis is often visible, and Thoth occasionally so, that is to say, it is sometimes invisible for several years at a time. See Bulletin 8 of the Lowell Observatory. This year all three of these canals were perfectly obvious, and the last two equally so. The drawing was made January 18, 1914, except for the two faint canals Orontes and Phison, which were inserted on it from drawings made upon January 10, 11, and 12. In order to make them clearly visible their conspicuousness is considerably exaggerated in the drawing. The case of Thoth is an unusual one. According to Schiaparelli it was visible at the oppositions of '77, '79, '82, '84, '86, and '88. It was not seen by the writer in '90 or '92, nor by Lowell in '94, '96, '99, or '01 but it was conspicuous to him in '03. It is not recorded by the observers of the Brit. Astron. Assoc. in '05 or '07 but was traced faintly by Lowell, and more conspicuously by Antoniadi in '09. It was clearly visible to M. Jarry Desloges and his assistants at the opposition of '11.

As far as the conspicuousness of the Martian canals is concerned when seen under favorable conditions, the more conspicuous ones are about as readily seen as the Mare Frigoris, the broad northern canal, upon the moon, when viewed with an opera glass. The two fainter canals, Figure 2, were less conspicuous than many of those shown in Figure 1. Other canals of intermediate visibility are found on Mars, and the writer feels therefore no question but that the two faint ones shown in the sketch were really there, as fairly uniform continuous markings.

A study of the lunar canals calls to our attention an unlooked for characteristic. We should naturally expect that as we approached nearer and nearer to the photograph, or used higher and higher powers upon the moon, that while the canals first seen would be resolved and exhibited in their true aspect, that other finer canals would appear, which a closer approach would in their turn resolve. On the moon, excepting with very low powers, this does not seem to be the case. It is true that with a power of several hundred diameters short uniform canals make their appearance, resembling in all respects the short stout canals in the Solis Lacus region of Mars, (Harvard Annals **53** 75), but the long narrow canals, hundreds of miles in length, so characteristic of Mars, are seen on the moon only with such low powers as we have just described. It must be noted that in the case of these canals, their size and appearance do not vary in any way with the aperture, but only with the magnification. Of this any one can readily satisfy himself.

As we reduce the aperture of the field-glass, a slight improvement in distinctness is noted when we reach a size of about one-quarter of an inch, on account of the reduction of the glare, but when the aperture gets below one-eighth, or a magnification of 32 to the inch, they become less distinct again. They continue to remain visible and to be of the same breadth and in the same place, until with failing light they gradually fade from view.

In the case of the moon an equivalent distance of 80,000 miles seems to produce the best effect. At less than 30,000, and at more than 150,000 miles, the canals disappear as such, and are replaced in the former case by more or less irregular, but still elongated markings.

On the moon, even with the naked eye, the dark canal shaped marking ending in the Mare Nectaris is obvious. Mare Frigoris too can easily be seen. Their appearance on a photograph of the full moon, and that of the F-shaped marking presently to be described indicates what the writer believes the canals of Mars would be like could we see them more clearly. It is perhaps worthy of remark in this connection that it is quite impossible to tell from a near inspection of a photograph of the moon, just where the canals will appear when it is seen from a

distance. Thus, one might naturally expect that the F-mark would be prolonged as a canal nearly as far as Tycho. Such however is not the case. On the other hand one would never have expected the area lying between Tycho and Nectaris to appear from a distance as a double canal.

This canal so conspicuous in the opera glass, makes a severe test of acuteness of vision for the naked eye. If the moon is high, a shade glass will help one to distinguish it, but it can hardly be detected as a canal, earlier than a day or two before full moon. Few of the Martian lakes are ever as conspicuous as Mare Crisium to the naked eye, but they are comparable to some of the lakes shown in Figure 1 as seen with an opera glass, and their visibility might be recorded in that way. It is probable that the same law applies to the canals of Mars, and if we were only able to use a little higher power, when Mars was nearest to us, the canals would vanish, and be replaced by the real details which the canals merely indicate. During our Arequipa observations of Mars in 1892, when the planet was unusually near us, many of the canals presented a broad hazy appearance, which later, when more remote, was replaced by the effect of the very narrow dark lines. We used a low power of 350 most of the time, because we wanted to see the canals! Had we used a higher power, we should perhaps have seen what was really there.

The surface of Mars appears to be particularly well adapted to producing the canal effect. Only isolated areas upon the moon show it to advantage. This may be because the bright areas of the moon are too rough, and the smooth areas too dark,—for even on Mars the canal effect is conspicuous only in the bright regions. Again, on account of the more abundant vegetation on Mars, it is possible that stripes on the planet are more frequent, for it must be remembered that the basis of every canal is really a stripe, although the increase of blackness may be slight and the breadth great and irregular. The presence of lakes at the two ends of a canal will render it much more readily visible, though they will not produce a canal if there is no real shading between them. It might be suggested that a new and temporary canal on Mars might appear in any region if bounded on either side by a faint band of haze or cloud. At every opposition, by using the proper magnification, 300 to 600, some canals should be seen, and if they are not, it merely indicates that the definition is inferior. The better the definition, quite regardless of the aperture of the telescope, the more clearly will the canals appear.

In our sketch of the moon the shape and location of the *maria*, and the positions of a considerable number of the bright craters are in fair agreement with what we know to be the case, as based on photographs,

and the use of higher telescopic powers. To the left and above the center of our figure, shaped like a letter F, are several short thick canals and a number of lakes, which are also in fair agreement with the facts. On the other hand our long thin canals give little or no information as to the real appearance of that portion of the surface. In spite of this fact the canals of Mars are well worth while observing, because they change with the seasons, and also differ from year to year at the same season on Mars. This is perhaps the most artificial feature. If the observer desires to study them to the best advantage, then the only way to do so is to draw them as they appear. Sometimes many of them appear as straight narrow dark lines. The fact that they may not really be narrow, or perfectly regular is no reason why they should not be carefully studied and named, and all honor should be given to Schiaparelli, who although not their discoverer, was the first to observe them in large numbers, and to draw general attention to their existence. Still we must remember, at the best they are only indications of detail, not the real thing. That is to say what they indicate is something that is actually beyond the power of the observer's telescope to correctly define.

If we had employed an eyepiece with our 11-inch telescope last January giving a magnification of 110, the more conspicuous canals, such as Nilosyrtis and Thoth would have been seen, and the emergent pencil of light would have been just one-tenth of an inch in diameter. The diameter of the planet at that time was 14″ and the breadth of these two canals was about one-thirtieth as great, or 0″.47 equivalent to 140 miles. In a well lighted room the diameter of the pupil of the eye is about one-tenth of an inch. If now we place Figure 2, which is 45 mm (1.75 inches) in diameter at a distance of six meters (20 feet) from the eye, it will be on the same scale that Mars would have appeared in the telescope, with a power of 110. The breadth of the canals will be 0″.47 × 110 or 52″. If we wish to see how the planet looked with a magnification of 330, we simply view the drawing at one-third the distance, but we must look at it through a large pin-hole 0.85mm (1/30-inch) in diameter. This should be made in a piece of black paper, and the drawing placed in a bright light in order to secure sufficient illumination. Since it is difficult to produce a pinhole of exactly the right size, without microscopic measurement, the reader may have to use a slightly different distance from that here given in order to get the proper effect. The writer usually prefers a magnification of 660 in his work, the effect of which may be produced by placing the drawing in the sunlight, and viewing it from a distance of 40 inches, through an aperture 1/60 of an inch in diameter.

In Figure 3 various lines have been drawn, the first one, A, to represent the canals as shown in Figure 2. When placed at the proper distance to represent the planet, however, it will be noticed that the second line B represents the canal quite as well as the first one, so we really do not know but that the canal may be one-quarter as wide again, and fainter. If it were wider than that however, and still fainter we should detect the difference. This drawing therefore gives us a maximum breadth for the canal. It may also be represented by a line C of three-quarters its breadth, and the proper density. It cannot however be darker than this and narrower. The martian canals therefore are not black.

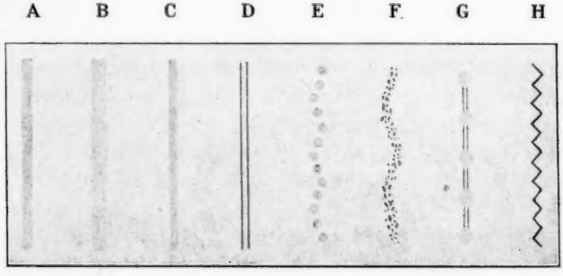


FIGURE 3.

It may be equally well represented by two narrow parallel lines whose centers are at a distance of two-thirds the breadth of A. These lines cannot be resolved into a pair until we approach within about half the distance. Provided the lines are dark enough to be easily seen, dark and light doubles are resolved with nearly equal ease. With an aperture of 1/30 of an inch, the ratio of separation to distance is as 1 to 1000 or an angular separation of 206″. With an 11-inch objective we may obtain an emergent pencil 1/30 of an inch in diameter, by using a magnification of 330. This would give 0″.62 as the smallest resolvable angle for parallel dark lines. This compares with a separation of 0″.42 found for a 15-inch telescope by actual trial on an artificial disk, (H. A. **32** 149), and is about fifty per cent greater than that usually accepted for double stars.

It is not likely therefore that the separation of the double canals upon Mars or in Aristillus was less than 0″.6 in place of 0″.5, as stated in Report No. 5. The fact that the Aristillus double was continued outside the crater as two diverging and easily separable canals would seem to indicate that the duplication was real in that case and not merely apparent, but the fact that the angular separation observed should be the same for both the moon and Mars is certainly a very suspicious circumstance.

Returning to Figure 3, the canal E is composed of a zigzag line of dots. The dots cannot be smaller or darker if a single row is employed, and unless they are placed more nearly in a straight line they cannot be confused with canal A. If there are more dots and they are scattered irregularly as in F, they cannot vary so much as these do from a straight line. The canals cannot therefore be very sinuous, nor indeed depart far from straight lines of uniform breadth. G shows the maximum possible size of the dots and H a continuous sinuous line like a river.

It therefore appears that the two canals Thoth and Nilosyrtis are not in reality more irregular than these later lines, and we have accordingly found an upper limit to any sinuosities or irregularities that they may contain. We see therefore that they are fairly uniform structures 1000 and 1500 miles in length by 150 miles in breadth, and are consequently quite unlike anything existing upon the earth. They cannot for instance be sinuous like our rivers, nor tapering, nor composed of dots accidentally located, so as to produce on us the impression of a continuous line.

On the other hand the finer canals, which may be represented by Figure 3 if we view it from double or treble the distance, cannot be distinguished from any of these irregular lines, and we consequently cannot say with certainty what their outlines are really like, or whether they are single or double. As there are canals of varying intermediate grades however, it seems fair to assume that all are of the same general structure, and all fairly uniform in shape. We may note one difference nevertheless. All of the larger and more conspicuous canals are curved. The fainter ones on the other hand usually appear straight.

The canals encircling Elysium were distinctly elliptical in outline this year, the major axis of the ellipse lying northeast and southwest in the terrestrial sense (*n. p.* and *s. f.*). The dimensions measured from four drawings were as follows:—December 15, 1450, 950 miles. December 16, 1450, 950 miles. December 17, 1200, 850 miles. January 20, 1250, 900 miles. The outline as drawn by the members of the British Astron. Assoc. at the oppositions of '99, '01, '03, '05 and '07 may be described in general as circular, but with a pronounced angle at the south. The diameter of the circle ranged from 1550 in 1901 to 1350 miles in 1903. It would appear therefore that the circle was flattened rather than lengthened this year. The loss of the angle, and the flattening noted are either of them sufficient to show that the canals do sometimes shift laterally from year to year. In 1911 M. Jarry Desloges and his assistants drew Elysium as a pentagon with straight sides, the southern and eastern angles being rather more marked than the other three. This would seem to make the case of lateral shift still stronger.

The most striking difference between the lunar and martian canals is that the latter are much more variable both in density and position, and often are entirely invisible. The former vary a little in density with the colongitude, which corresponds with the season upon the moon. Those lunar canals visible with a field-glass we shall designate as the coarser canals; those visible in the telescope we shall call the finer ones. With the latter we have the same difficulty as in the case of Mars, they appear perfectly straight and uniform, and as we saw in our last Report, in some cases they may even appear double.

The gradual narrowing of the canals with the progress of the season was well shown at this opposition. Nine canals were selected that were well seen at at least three presentations, and the breadth measured on the drawings. Where several drawings were available for the same presentation, which happened occasionally, the best one only was used. In Table I the first column gives the date, the second the longitude ☉, the third the equivalent martian date, the fourth the measured breadth of the canal on the drawing in millimeters, the fifth the measured diameter of the planet, and the last the deduced breadth of the canal in miles.

TABLE I

BREADTH OF THE CANALS.

1913-4	☉	M. D.	B	D	Miles
		CERBERUS.			
Sept. 2	312.5°	Jan. 30	0.7	21	140
Nov. 17	353.3	Mar. 13	2.5	34	310
Dec. 17	8.1	" 28	1.3	44	120
Jan. 20	24.1	Apr. 13	1.6	43	160
Feb. 25	40.4	" 29	1.2	31	160
Apr. 9	59.1	May 18	1.0	22	190
		NILOSYRTIS.			
Sept. 30	328.2	Feb. 15	1.0	25	170
Nov. 7	348.2	Mar. 8	2.6	33	330
Dec. 10	4.7	" 24	1.6	41	160
Jan. 17	22.7	Apr. 12	1.8	44	170
Feb. 24	40.0	" 29	0.4	34	50
Mar. 31	55.4	May 15	1.0	23	180
		THOTH.			
Sept. 30	328.2	Feb. 15	1.1	24	190
Nov. 7	348.2	Mar. 8	2.0	33	250
Dec. 10	4.7	" 24	1.8	41	180
Jan. 17	22.7	Apr. 12	1.9	44	180
Feb. 24	40.0	" 29	1.3	34	160
Mar. 31	55.4	May 15	0.9	23	160
		SABAEUS.			
Oct. 30	344.1	Mar. 3	3.0	30	420
Dec. 3	1.2	" 21	2.0	40	210
Jan. 10	19.4	Apr. 8	1.9	45	180
Feb. 14	35.2	" 24	2.0	35	240
Mar. 26	53.2	May 12	1.9	25	320

		HYBLAEUS.			
Nov. 7	348.2	Mar. 8	1.3	33	170
Dec. 16	7.6	" 27	1.0	43	100
Jan. 20	24.1	Apr. 13	1.1	43	110
Feb. 25	40.4	" 29	0.6	32	80
		HADES.			
Nov. 17	353.3	Mar. 13	1.9	34	240
Dec. 17	8.1	" 28	2.0	44	190
Jan. 21	24.6	Apr. 13	2.0	42	200
Feb. 25	40.4	" 29	0.8	32	100
		STYX.			
Dec. 17	8.1	Mar. 28	3.7	44	350
Jan. 20	24.1	Apr. 13	1.5	43	150
Feb. 25	40.4	" 29	0.6	32	80
Apr. 9	59.1	May 18	1.0	22	190
		TARTARUS.			
Oct. 12	334.6	Feb. 22	4.5	27	700
Dec. 18	8.5	Mar. 28	5.0	44	480
Feb. 1	29.6	Apr. 19	1.5	42	150
		ORONTES.			
Oct. 30	344.1	Mar. 3	1.6	30	224
Jan. 20	20.4	Apr. 9	1.1	45	100
Mar. 21	51.0	May 10	0.6	24	100

It is to be noted however that the narrowing is not continuous but fluctuating. One of the best illustrations of this occurred in the region bounded by the canals Ganges, Nilokeras, and Jamuna. This region lies between the chief of the northern marshes, Mare Acidalium, and the southern *maria*. It lies therefore exactly in the course that we should expect much of the water would take on its way from the northern polar cap to the southern hemisphere.

In Table II are given the date of observation, the diameter of the planet, the longitude of the Sun ⊙, and the breadth of the Ganges and Lunae Lacus in miles. Every observation made of this region is entered. When they were invisible, as indicated by the —, it was not from bad seeing, except perhaps at the very beginning and end, but from martian conditions, probably clouds. In the first observation of December 1, Ganges was narrower at its southern termination, and did not quite reach Aurorae Sinus, in the second, made a little over an hour later, it fell nearly 300 miles short of it. This change is ascribed to cloud. On December 4, January 5, and April 21 the narrowing near Aurora was very marked. February 5 it was invisible because too near the limb. Lunae Lacus was generally of well defined breadth and connected with Acidalium, but on September 17 it was large and indefinite in outline. On February 5 and 7 it was quite separate and brownish, and on April 21 was joined to Acidalium only by a narrow line. In the last two cases its equatorial diameter was greater than its polar.

The shading was generally too faint to show color. Possibly it was due to moist ground. As in a number of other cases, it will be noted that the canal first appears narrow, then rapidly broadens, and then slowly narrows again.

TABLE II.

GANGES AND LUNAE LACUS.

1913	Diam.	⊙	G	L	1914	Diam.	⊙	G	L
	″					″			
Aug. 6	6.5	296.6	—	—	Jan. 5	15.0	17.1	4-1200	1200
Sept. 13	7.6	318.7	50	—	Feb. 5	12.4	31.4	i	500
17	7.8	320.9	400	l	7	12.2	32.3	—	6-900
Oct. 19	9.5	338.3	—	—	8	12.0	32.8	50	800
Nov. 26	12.7	357.8	120	—	10	11.8	33.7	—	1000
28	12.9	358.8	—	600	12	11.6	34.6	300	700
Dec. 1	13.2	0.3	3-500	600	Mar.13	8.8	48.3	600	300
"	"	"	700	800	20	8.4	50.6	700	700
2	13.3	0.8	1600	1600	21	8.3	51.0	—	—
3	13.4	1.2	600	900	Apr. 21	6.5	64.2	2-400	6-900
4	13.5	1.7	3-600	900	May 29	5.3	81.6	—	—
30	15.0	14.2	—	1100	June 3	5.2	83.4	—	—
31	"	14.7	700	700					

It now only remains for us to draw whatever conclusions may seem probable with regard to these interesting objects, since it does not seem likely that any further light on their nature will be gained, at least as far as Mars is concerned, before the next opposition. It is believed that Lambert was the first to suggest that the reddish areas of Mars owed their color to vegetation. The suggestion that they were simply desert regions, while the dark areas and canals were due to vegetation, instead of water, was of comparatively recent origin.*

The writer believes that both types of lunar, as well as the martian canals, are due to vegetation. Indeed no other explanation seems possible when we stop to consider the facts. It does not seem possible that the lunar canals can be artificial, but the martian ones act differently from them in some respects, notably in their great variability, and if we may so express it, their apparently unnatural conduct, some appearing during one martian year, and others during another, at the same season. They act indeed almost as if there were some guiding intelligence behind them. Their uniform breadth, straightness, and occasional circular or elliptical forms are waived as arguments, because perhaps they are not really quite as regular as they appear, and because we find something very similar upon the moon. It is to their changes that we should especially direct our attention, and regarding which future observers should secure all possible data.

* Science 1888 **12** 82.

The martian atmosphere as far as its permanent constituents are concerned we know to be more or less rarefied. The amount of water vapor it contains on the other hand, in the presence of ice or water, depends exclusively upon the temperature. When the polar caps are melting rapidly therefore, and large liquid surfaces present themselves in the marshes, the atmosphere may, at ordinary terrestrial temperatures, be composed in a very large part of water vapor. At other times it may contain very little. The question of the martian seasons should be considered very carefully in any future attempts to detect the presence of water vapor by means of the spectroscope. One of the most careful and painstaking attempts hitherto made to secure evidence of of the presence of water vapor upon Mars was made during the dry season upon the planet.

Assuming that the canals are due to vegetation, we must further assume either that they are, or are not artificial. Assuming first that they are, we shall find that three attempts have hitherto been made to explain them.

(*a*) They were formerly supposed to be fertilized by invisible irrigating ditches or conduits. The difficulty with this idea is to maintain the necessary circulation of water. Professor Lowell when he adopted it suggested that the circulation was maintained by pumping. To this it is replied that that would require altogether too great an expenditure of energy, when the problem is reduced to figures. Indeed the formation of the polar caps is sufficient of itself, as Professor Douglass long ago pointed out, to show that the planetary circulation must be in large part atmospheric, and not due, except at the very beginning, to artificial canals. If it is atmospheric in part, it might as well be wholly so.

(*b*) It was suggested a few years ago* that the canals consisted simply of a growth of dark vegetation like trees or bushes upon grassy or semi-arid plains of a lighter color, all being supported by water derived from the natural aerial circulation of the planet. The beauty of this plan consists in its extreme simplicity, and the fact that such canals actually exist upon the earth on a small scale, constructed in this manner for good and sufficient reasons, though presumably not the same ones, namely protection for herds of cattle against winter storms. The difficulty however is to account for the shifting of the canals.

(*c*) In an atmosphere saturated with moisture, fogs should readily form at night, which would disappear to a large extent in the daytime. This frequently occurs at certain seasons, notably the early autumn, upon the earth. Since the surface of Mars seems to be extremely flat, it is suggested that these fogs instead of being permitted to exhibit a

* Harper's Monthly Magazine 1908, 192.

general accidental distribution, might be localized night after night in certain selected regions artificially. It is known as a laboratory experiment that fog can be induced to form in a saturated atmosphere, if furnished with a sufficient number of minute solid nuclei on which it may condense. It is suggested that it might be practical to do this, either by electrifying the air in certain regions, night after night, or by some such similar means upon a large scale on Mars. Where the fogs condensed at night vegetation would appear by daylight, when the fog cleared away. As a matter of observation fog is often seen on the sunrise limb of the planet, and it does in general clear away as the sun rises higher upon it. Occasionally however it persists throughout the day, particularly near the northern boundary of certain dark areas, such as Sabaeus and Cerberus, as noted in our Report No. 3. A certain shifting of the fertilized areas from time to time would doubtless insure improved crops if the water supply were insufficient to fertilize the whole, so that we can readily see an object for it. If on account of accelerated growth due to greater moisture the vegetation ripened, dried up, and died first, along the medial line of the canal, we can account for the apparent duplications sometimes observed. In our Report No. 4 we saw that marshes did actually appear to advance and change their positions in this manner, following clouds or fogs produced by evaporation from their surfaces. The difficulty with this explanation is the question whether it would be possible in a saturated atmosphere overlying a uniform surface, to select any locality at will over which a fog should be produced.

Assuming now that the canals are due either to vegetation or to any other cause, but that they are *not* artificial, we find that to frame a plausible hypothesis that will explain the changes hitherto observed is a matter of extreme difficulty. The only natural agencies at our disposal capable of producing such changes, seem to be either volcanic or meteorological. The latter appear to be the more promising, although many of the lunar canals lie along volcanic cracks. We may modify either (*b*) or (*c*) by substituting for intelligent design the accidental shifting of the winds, bringing more moisture, and causing certain kinds of vegetation to flourish. To support a single canal 2000 miles long by 500 miles wide would seem to require too much volcanic activity. Such suggestions involve added hypothesis and are therefore unsatisfactory. It may fairly be said that no satisfactory explanation, based on purely natural causes, has as yet been suggested to account for the changes observed on Mars.

It is not considered by the writer however that any of these hypotheses are sufficiently well supported as yet, to justify us in such a momentous conclusion as the decision that intelligent animal life now

exists upon Mars. To the majority of scientific men probably nothing short of the reception of a series of intelligible signals would be considered sufficient evidence to lead to such a decision. These theories of the canals are mentioned here, not because the writer feels assured that any one of them is right, but simply because (*b*) and (*c*), at least seem to him, to account for the observed facts more readily than any of the others, and because he feels that any theory, even a false one, is better than none at all. To the direct question so often asked, however, is Mars inhabited by intelligent beings, we must, and probably long shall be obliged to reply simply, possible but not proven.

Turning now from mere speculation to plain fact, the latitude of the southern boundary of the northern snow cap between March 20 and April 15 increased only from 71°.2 to 72°.5, showing a very slow rate of melting, of less than 50 miles in 26 days. There was thought to be a slight accession to its diameter between March 21 and 26. On the latter date at 12^h G.M.T. it was suspected that the southern polar cap was as bright, or almost as bright, as the northern. This might mean snow near the south pole. If so, it was the first we had seen. It lay in longitude 280°, latitude −60°, and the martian date corresponding was May 12, which for their southern hemisphere corresponds to our November. The south pole itself and all of the planet south of latitude −71° was hidden from view in the polar night:

Cloud was less marked in the extreme southern latitudes than during the previous months, and often the region was found to be perfectly clear. Indeed little cloud was seen anywhere excepting on a few dates. The southern *maria* retained their green color in some places, and Acidalium was occasionally reported as blue. Comparatively few canals were seen, doubtless on account of the great distance of the planet. The following however were observed.

Mar. 20 **1** Nilokeras, Jamuna, and Ganges as one broad hazy band.

Mar. 21 **1** Three broad very faint shadings radiating from Acidalium towards Sabaeus, Margaritifer and Aurora. Doubtless they will later concentrate into canals.

Mar. 26 **6** Orontes, Typhon, Euphrates, Hiddekel, Gehon, Deuteronilus, and Ismenius lacus.

Mar. 31 **5** Nilosyrtis, Thoth, Phison.

Apr. 9 **4** Cerberus, Hades, Eunostis, Tartarus and Trivium Charontis.

Apr. 15 **3** Titan.

This last drawing shows Sinus Titanum considerably to the south and east of Schiaparelli's position, in longitude 160°, latitude −32°.

TABLE OF DATA.

No.	1914	⊙	M.D.	Long.	Lat.	Sun	Diam.	Seeing
		°		°	°	°	″	
63	Mar. 20	50.6	May 10	60	+5	+18	8.4	7
64	21	51.0	"	43	"	"	8.3	8
65	26	53.2	12	328	+6	+19	7.9	10
66	"	"	"	342	"	"	"	10
67	"	"	"	0	"	"	"	8,9
68	31	55.4	15	296	+7	+20	7.6	11
69	Apr. 9	59.1	18	226	+8	"	7.1	9
70	12	60.6	20	160	+9	+21	7.0	—
71	15	62.0	21	160	"	"	6.8	8

AN INVESTIGATION OF THE 9.4-INCH OBJECTIVE OF THE SHATTUCK OBSERVATORY OF DARTMOUTH COLLEGE.

H. T. STETSON.

In the remounting of the equatorial telescope of the Shattuck Observatory provision was made for a new flint lens, interchangeable with the original flint, its use converting the Alvan Clark visual into a photographic objective of 320cm focal length. Shortly after the change was made a series of extra-focal plates was taken for an investigation of the aberration errors of the lens.

The now well known method devised by Hartmann for determining the zonal errors of astronomical objectives has been reviewed somewhat extensively in the *Astrophysical Journal* by Plaskett,* and by Fox,† and needs no detailed description in this connection.

For the investigation of the 9.4-inch (239mm) objective of the Shattuck Observatory the screen used in front of the lens had 44 holes distributed in zones ranging from 28mm to 115mm radii. The variations in the focal readings for the separate zones are shown in Table I, where the numbered columns represent the results for separate pairs of plates,—the final column giving the mean for each zone. These results are shown graphically in the curve of zonal errors, Fig. 1. The radii of the zones are drawn as abscissae and the corresponding focal readings as ordinates. The separate curves numbered 1, 2, 3, 4, represent the result of four independent determinations and are all in general agreement, giving the mean curve indicated in heavy line. Examining the mean curve we find the two widest departures occurring at R = 56mm and R = 84mm respectively. Otherwise a slight increase

* Ap. J. **25**, 195, 1907.

† Ibid **27**, 238, 1908.

TABLE I.

ZONAL FOCI.

Radius	ϕ	1	2	3	4	Mean
115 mm.	0°	125.08	125.18	125.27	124.95	125.12
	90					
108	67.5	125.69	125.77	125.44	125.31	125.55
	157.5					
100	22.5	125.44	125.61	125.42	125.21	125.42
	112.5					
92	45	125.45	125.63	125.44	125.03	125.39
	135					
84	0	124.91	125.00	125.15	124.94	125.00
	90					
75	67.5	125.45	125.46	125.44	124.85	125.30
	157.5					
66	45	125.48	125.54	125.38	124.86	125.29
	135					
56	0	124.38	125.00	124.91	124.15	124.61
	90					
47	22.5	125.17	125.69	125.26	124.75	125.22
	112.5					
38	0	125.47	125.45	125.49	124.67	125.27
	90					
28	0	125.09	125.41	125.33	124.48	125.08

Mean 125.21

of focus with zonal radius is indicated. The greatest deviation from the mean is 0.6mm in zone R = 56mm, but the total variation between extremes is less than 1 mm or about 0.03 per cent of the focal length of the lens. The vertical displacement of the separate curves as a whole, is due chiefly to different temperature conditions at the time of exposure. The distribution of the astigmatism in the lens shows but slight tendency to systematic arrangement.

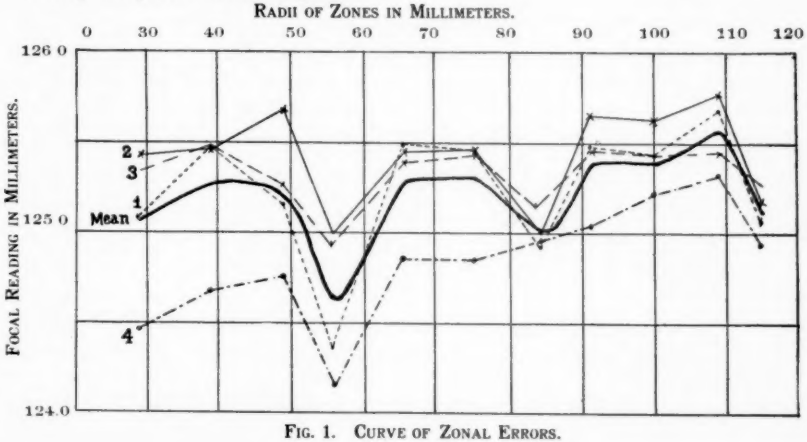


FIG. 1. CURVE OF ZONAL ERRORS.

The effect of the variation in focus on the formation of the image is made apparent in the diameter of the confusion disk in the focal plane of the instrument, and the quality of the lens may be judged accordingly. Hartmann adopts a "criterion" T, which is equal to the weighted mean diameter of the confusion disk in that plane F_0 where the circle containing all the converging pencils is smallest. The diameter is expressed in hundred thousandths of the focal length, F. The weights assigned are proportional to the light gathering power of the zones, or according to their radii r, and T is computed as follows,

$$T = \frac{\Sigma\, rd}{\Sigma r} \cdot \frac{100{,}000}{F} = \frac{2\,\Sigma\, r^2\,(F - F_0)}{\Sigma r} \times 10^5$$

In an investigation of the Yerkes Objective, Professor Fox has shown that perhaps a more representative value for T could be obtained in freeing F_0 from its dependence on any given zone.* This may be accomplished by choosing for F_0 that plane where the mean weighted diameter of the confusion disk (Σrd) is a minimum. All lenses for which $T < 0.5$ Hartmann characterizes as first class, "hervorragend gute", astronomical objectives. For the ideal lens $T = 0$. For the nine-inch Shattuck lens the mean of the several plates gives, according to Hartmann's definition $T = 0.33$. For Σrd a minimum, $T = 0.30$. The apparent diameter of the confusion disk in seconds is readily found by multiplying T by $2''.063$ ($= 206264'' \times 10^{-5}$).

The diameter of the confusion disk becomes an important factor in the resolution of close doubles. We could not well expect to resolve two stars whose angular separation is much less than the diameter of the confusion disk, unless the light from the star showed marked concentration toward the center of the disk. On theoretical grounds alone two stars to be clearly separated must not be at less distance than the angular diameter of the central diffraction disk for the given aperture and wave length of light. It is therefore of interest to compare the mean diameter of the confusion disk with that of the diffraction disk, in a few instances of different apertures, as shown below.

Telescope and Aperture	Yerkes 40-in. (1020 mm)	Dominion 15-in. (381 mm)	Shattuck 9.4-in. (239 mm)
Criterion T (Hartmann)	0.20	0.29	0.33
Diameter of Confusion Disk	0″.41	0″.29	0″.68
Diameter of Diffraction Disk	0″.27	0″.74	0″.94

In considering then the working value of a given lens we need to consider both the diameter of the confusion disk which is due to resid-

* Ap. J. **27**, 242.

ual errors in aberration, and the theoretical diameter of the diffraction disk. Although the ideal lens of any aperture would have no aberration errors and hence a value *zero* for the diameter of the confusion disk, yet, as will be seen from the above table, it is more important that the confusion disk be small for lenses of large apertures than for those of smaller proportions. From the point of view of the confusion disk alone the 40-inch lens is superior in workmanship to the 9-inch, as would be shown by Hartmann's criterion; but when we regard the theoretical diffraction disk in the two cases we see that for the 40-inch the confusion disk is nearly double the diffraction disk, whereas for the smaller lens the confusion disk is about two-thirds as large as the diffraction disk. It would seem then that a numerical "criterion" to represent the effective working quality, or we might say the optical efficiency, of an objective should involve both these quantities. One can not, however, overlook the fact that the diameter of the confusion disk as derived from the Hartmann criterion is at best considerably uncertain. As could be easily shown the value of T might be made to differ widely for the same lens according to the particular zones chosen for the investigation. Even at best this numerical criterion must be received with caution.

At a later date it is hoped to publish some results obtained in an investigation of the distribution of light in the confusion disk and its consequent effect upon the star image and the resolving power.

Dearborn Observatory,
Evanston, Ill.

THE TOTAL LUNAR ECLIPSE OF MARCH 22, 1913.

ALBERT S. FLINT.

Very few reports of this eclipse appear in POPULAR ASTRONOMY. Professor Barnard, in the May number, presents the most detailed observations, and raises the question whether it was not an unusually dark eclipse. I supposed that many amateurs would watch the phenomenon and report anything noteworthy. It may be well, therefore, for me to send in the note of my observation written immediately afterward.

I observed from the roof of my house, which commands a view to the west and south down to the ordinary horizon, but is backed on the east by the University hill with its trees and high buildings. These served probably in some degree to delay the obliterating effect of the

dawn. The instant I stepped on the roof, when the eclipse was already well advanced towards totality, I noted that it was an extremely dark eclipse. The sky seemed remarkably clear, down to the horizon all around. It is my impression that my written record following was meant to refer entirely to observation through the opera glasses which I had in hand. Words in parenthesis are added now to fill out the meaning.

"Disk five-sixths covered (by shadow): plain horn of light on upper (eclipsed) limb, but remainder (of dark part of moon) invisible. When only a thin cresent (of bright light) was left, nearly the entire disk appeared in a dull, red glow. Could (now) distinguish houses in the dawn two blocks away. At 5:20, (Central Standard Time), the moon became completely invisible. Could now distinguish houses on University Heights (about half a mile away to the southwest.)" Totality lasted, according to the Ephemeris, from 5:11 to 6:44, and the sun rose here at 5:58. It is difficult for me to believe that any but a remarkably dark eclipsed moon could have disappeared entirely in the degree of dawn indicated in my note.

The observations reported in POPULAR ASTRONOMY, as bearing on the darkness of the eclipse, I have epitomised for each observer as follows. Explanations of my own are enclosed in parentheses.

Northfield. "Totality at 5:12. Faint glow still on west edge of moon at 5:16." (Presumably the remainder of the disk was very dark, at least darker than "faint".)

Barnard, Williams Bay. "4:40, (moon nearly one-half covered by shadow)—Visibility of eclipsed portion uncertain, even when (bright part) occulted by a tree.

"5:09. Very thin, feeble crescent. Only faintest traces of eclipsed portion.

"5:12. Not total yet, but very dim. No trace of eclipsed portion. Daylight strong everywhere.

"5:19 Moon entirely disappeared. 5:20. Sky white from daylight."

Newton, Irvine's Landing, B. C. "5:20 Pacific Standard Time. Edge of shadow near moon's center. A dark eclipse!! The eclipsed area is faintly visible to my naked eye. 5:55. Strong dawn."

Dr. Gray, Eldridge, Calif. "Night showery. Just after 3:00 Pacific Standard Time sky clear in patches. Moon so dark it was some trouble to locate it. Many persons, not knowing just where to look, missed the eclipse altogether. 3:20 to 3:50 eclipse observed well through field-glasses, telescope, and finder. Dull, coppery hue of the disk seen plainly in all the instruments."

It is to be regretted that more reports have not come from the mountain belt, as the weather map showed clear weather generally in that

region, while clouds prevailed in the east, and along the Pacific Coast, It would be interesting if some of our amateurs, having access to the government records, from ships at sea as well as from land stations. would collate meteorological data from the rim of the world as seen from the moon during particular eclipses. Then the assertion in the books, that the degree of brightness of an eclipse is due to the clearness of the earth's atmosphere around the rim, might be verified. And from a careful study of the distribution of the light on the eclipsed moon, some desirable information might be gained as to the aggregate state of the atmosphere at the time in some comparatively inaccessible portion of the earth, as the polar regions for instance.

Madison, Wisconsin, April 2, 1914.

THE PROBABLE EFFECT OF RADIOACTIVITY ON THE DEATH-RATE OF THE SUN.

W. CARL RUFUS.

The source of the sun's radiant energy is one of the most interesting problems of solar physics. To maintain the present rate of radiation by combustion alone, a thousand years would suffice to consume the entire mass of the sun, if it were pure coal and oxygen. A sphere of the sun's temperature and mass, with unit specific heat, radiating by cooling alone, could continue the present rate about three thousand years. Moulton has proved the insufficiency of the meteoric theory of the source of the sun's heat.* One kilogram of meteoric matter falling into the sun generates the enormous sum of 45,815,624 calories. Yet limited to this source of heat, the sun would contribute to the earth only 236 times as much heat as that planet receives from the direct impact of meteors upon its own surface. But the earth receives a vastly greater proportion of heat from the sun than from the fall of meteors, so this theory fails quantitatively. Helmholtz's theory of contraction under gravitation is considered sufficient by some authorities. Abbot says†, after suggesting that the former radiation of the sun may have been less than the present, "On these grounds we may consider Helmholtz's contraction hypothesis as adequate to satisfy the requirements of geology and physics in regard to the source of the sun's

* Celestial Mechanics, Second Revised Edition, p. 62.

† The Sun, p. 278.

energy." Young states that the solar radiation can be accounted for on this hypothesis necessitating an annual shrinkage of about 200 feet in the sun's diameter. Other estimates require from 250 to 300 feet. According to Newcomb, on this hypothesis the sun will have shrunk to one-half its present size in 7,000,000 years. On a similar basis of calculation the past duration cannot be more than 25,000,000 years. Lord Kelvin's probable age of the sun,* 100,000,000 years, determined by computing the lost energy of concentration of the sun from infinite expansion, appears to be rather large. G. H. Darwin† shows that this value would be reduced nearly one-half by using Langley's value of the solar constant instead of Pouillet's. Furthermore, by a slight change apparently necessary to satisfy the dynamics of the case, (an estimated increase of lost energy to allow for the concentration of the solar mass toward its center), Darwin reduces this time to 12,000,000 years. These periods seem rather short from the standpoint of geology, which teaches that the earth's temperature, dependent mainly upon the sun, has changed only a few degrees in 50,000,000 years, and that the earth has existed in about the same condition as at present for hundreds of millions of years, so other sources are sought to supplement the former theories and to diminish *the death-rate of the sun.*

The discovery of radioactive substances, their wide distribution, and vast store of energy, has suggested the possibility that radioactivity may contribute largely to the supply of solar energy.

The radioactive substances, uranium, thorium, radium, etc., possess remarkable properties. They spontaneously emit characteristic types of radiation, the α, β and γ, or Becquerel rays, whose penetrating power, action on photographic plates, relation to phosphoresence and fluoresence, effect on rare gases and electrified bodies, apparent freedom from reflection, refraction, and polarization, and whose deflection by a magnetic field are well known. Their most significant property from the standpoint of solar physics is their power spontaneously to emit radiant energy in the form of heat. Radium salts maintain a temperature higher than their surroundings, and regardless of exterior conditions radiate energy at a constant rate for years without apparent diminution of the source. This process at first appears to violate the physicist's law of the conservation of energy. Furthermore, the radiation is accompanied by a veritable transformation of matter, the decomposition of one element into others. New substances are produced, differing in chemical properties from the old. Indeed, new elements are evolved, revealing the instability of the atom. Since many substances, not

* Natural Philosophy, Thompson and Tait, Appendix E.

† Nature 68, 496, 1903.

classified as radioactive, possess radioactive properties, there arises the suspicion that all atoms are more or less unstable; though chemistry has considered stability an essential characteristic of an element.

The disintegration theory of Rutherford and Soddy here referred to is the most widely accepted explanation of these phenomena. The spontaneous atomic transformation is due to the internal energy of the complex atom, which consists of rapidly revolving electrons and magnetons, a sort of miniature planetary system. The large quantity of heat produced is considered the equivalent of the internal energy released during transformation; thus the law of the conservation of energy is maintained. In other words, the radiant energy is the kinetic energy of perturbed electrons whose enormous velocities cause their escape from the atomic system. The radioactive atom is then a storehouse of energy in the most concentrated form known to man. Radium n its emanation parts with three-and-a-half million times the heat energy per gram given off by the most heat-productive chemical reaction known, the union of hydrogen and oxygen to form water.*

Positive proof of the presence of radium and uranium in the sun is lacking. The absence of their absorption lines in the solar spectrum, however, does not prove that these elements are not present in the sun; for it is a well known fact that the Fraunhofer lines of the metals grow more and more feeble as the atomic weight increases. Hence, Abbot concludes that it is not surprising that uranium, (atomic weight 238.5) and radium (226.4) should not show spectrum lines, even though these elements are present in the sun.

The wide distribution of radium in the earth makes its presence in the sun seem probable. If the earth had solar origin, or the two bodies had a common source, which is in accordance with the most widely accepted hypothesis of the genesis of the solar system, then the presence of radium in the earth gives convincing evidence, though not a proof, of its presence in the sun. Rowland indicated his belief in the identical composition of these two bodies in the words quoted by Mitchell,† "If the earth were heated to incandescence it would give a spectrum the exact counterpart of that of the sun." The presence of radium in in stony meteorites,‡ although the origin of meteoric matter is uncertain, indicates the probability that it exists in the sun, especially when

* Report of the British Association, 1911, p. 15.

† POPULAR ASTRONOMY, XXI 6, 1913.

‡ R. T. Strutt, Proceedings of Royal Society of London A. 77, 485, 1906. Only one sample of stony meteorite was analyzed and three of iron. His conclusion is: "Iron meteorites contain little, if any, radium. Stony ones contain about as much as the terrestrial rocks which they resemble." Rutherford accepts the conclusion. Radio-Active Substances and Their Radiations, p. 653.

we take into consideration the growing conviction of the uniformity of matter throughout the universe. At least, we are certain that meteoric matter falling into the sun carries with it a certain amount of radium.

Helium, a product of radioactivity, is present in the sun. The experiments of Ramsay and Soddy furnished conclusive evidence that helium is produced by radium; and Rutherford has proved that the α-rays of radioactive substance are atoms of helium. 158 cubic millimetres of helium per year are spontaneously manufactured by one gram of radium at the rate of 3.4×10^{10} atoms of helium per second. Other experiments have obtained helium from uranium, thorium, actinium, and polonium. Since radium and uranium emit particles known to be helium atoms, and helium lines were detected in the "flash" spectrum of the sun before that element was discovered in the earth, we have reason to believe that its progenitors exist in the sun as well as in the earth.

Radio activity as a cosmic force was implied by H. Giebeler, who ascribed new lines in the spectrum of Nova Geminorum 2 to uranium, radium, and radium emanation* Although definite identification of the lines was practically impossible, the remarkable coincidences pointed out were confirmed by Kayser.† Snyder‡ attributes peculiarities of the spectra of early type Wolf-Rayet stars to radioactivity. He maintains that the solar chromospheric line, λ 5303.36, is due to alpha-hydrogen, and both chromospheric line and the alpha-hydrogen line are identical with the main coronal line. "Alpha-hydrogen as one of the products of radioactivity is found to luminesce in the vast radio spheres about sun and star, and there to demonstrate the balanced play between the forces of radioaction and gravitation."

The strongest statement implying direct evidence of the presence of radium in the sun comes from F. W. Dyson.¶ After discussing possible identifications of several chromospheric lines, and comparing them with lines in the spark spectrum of radium, he says: "It seems to me that these lines in the chromosphere may reasonably be attributed wholly or partially to radium. There is a general agreement with the radium spectrum as regards the intensities and the agreement of the wave-lengths is quite satisfactory." S. A. Mitchell‖ carefully examined the region of the spectra of radium and of the chromosphere considered by Dyson, but he believes that the coincidences are not sufficient to warrant a positive conclusion. Similarly, Evershed§ reaches a negative

* Astr. Nach. **191**, No. 4582.

† Ibid. **192**, No. 4583.

‡ POPULAR ASTRONOMY XIX. 3, p. 171. 1911.

¶ Astr. Nach. **191**, No. 4583.

‖ POPULAR ASTRONOMY XXI 6, p. 321, 1913.

§ Kodaikanal Observatory Bulletin, No. XXVII.

conclusion, both for radium and for radium emanation. We may well conclude with Jones:* "There is no direct evidence of the existence of radium in the sun. Notwithstanding the supposed fact that certain lines of radium have been described as occurring in the solar spectrum, these coincidences are so poor that we cannot accept the evidence." Nevertheless, negative results are far from satisfying, when indirect evidence is quite convincing and *a priori* reasoning makes the presence of radioactive substances in the sun seem quite certain.

Even though it could be proved that radium and uranium exist in the sun, we still have to consider their effect upon radiation. One gram of radium emits 118 calories per hour. An equal amount of coal entirely consumed would give only 500 calories, while radium suffers no sensible loss in weight during years of radiation. Rutherford reaches the surprising conclusion, "In the course of its life one gram of radium with its transformation products, including radium F, emits about 3.7×10^9 calories†." The presence of radioactive substances in the sun would then seem to be a sufficient source of solar energy. W. E. Wilson‡ calculated that the presence of 3.6 grams of radium in each cubic meter, or about 2.5 parts to 1,000,000 of the sun's mass, would be sufficient to produce the present radiation. This proportion is millions of times greater than terrestrial surface rocks contain, (5×10^{-12} grams per cubic centimeter), and more excessively greater than the proportion in the entire mass of the earth deduced from theoretical considerations,¶ (1.75×10^{-13} grams per cubic centimeter). Moreover, a constant supply of radium would be necessary to replace the amount used, or at the end of 1760 years, the half-life of radium, the present store would be half expended. The amount furnished by meteoric matter would be far too small, almost negligible compared with the enormous expenditure.‖ Rutherford says: "It appears that the heat emission of the sun cannot be seriously influenced by the presence of known types of radioactive matter, for a simple calculation shows that if the sun consisted

* New Era in Chemistry, p. 280.

† Radio-Active Substances and Their Radiations, p. 582.

‡ Nature **68**, 222, 1903.

¶ Strutt, Proceedings of Royal Society of London, A **77**, 480-481, 1906.

‖ A rough estimate, using Lane's determination of the fall of meteoric matter upon the earth (Science, **37**, 674, 1913) based upon Pickering's maximum values for their number and size, assuming that the number falling upon the earth corresponds to the number intercepted by the portion of the sun's surface cut out by a cone whose apex is the sun's center and whose base is the earth, adopting the proportion of radium in stony meteorites, 1.12×10^{-12}, according to Strutt, and neglecting the small percentage of iron meteors, gives 50,000,000 grams of radium per hour, capable of producing 6×10^9 calories. Solar radiation is about 3.2×10^{25} calories per hour.

entirely of uranium in equilibrium with its products the generation of heat due to active matter would only be about one-fourth of the total heat lost by radiation."

Atomic transformation of substances not classified with the radioactive remains to be considered. The supposed transmutation of certain elements has been chronicled at various times. One of the most authentic comes from Sir William Ramsay.* By applying the energy contained in niton (radium emanation) water, ammonia, hydrogen chloride, and carbon dioxide, were decomposed. Applied to salts of copper the metal copper appeared to be converted into lithium. Similar experiments indicated that thorium, zirconium, titanium, and silicon, are degraded into carbon. In the laboratory of the sun, subjected to enormous pressure and high temperature, atoms ordinarily stable may disintegrate with liberation of vast stores of internal energy. The order of magnitude of this atomic energy is beyond the range of present knowledge. Assuming that atomic energy varies with the atomic weight, a given mass of any substance possesses potential atomic energy of an order similar to that of radium. This assumption may be too low; since the more stable atom, requiring greater stress for its disintegration, probably emits particles with a higher order of energy.

If the entire mass of the sun, 1.99×10^{33} grams, possesses potential atomic energy of the order of radium, we can readily compute its total thermal store. During its lifetime one gram of radium with its descendants emits 3.7×10^{9} calories, so the sun would possess an equivalent of 7.4×10^{42} calories. At the present rate of radiation, 2.8×10^{33} calories per year, the supply would be sufficient for 2,600,000,000 years.

This period exceeds 25 times Kelvin's probable age of the sun and 200 times its age computed by Darwin; and it is nearly 200 times as long as the future duration of the sun determined from dynamical data.

* President's Address, Report of British Association for the Advancement of Science, 1911. p. 15.

STORY OF THE CAWTHRON SOLAR OBSERVATORY PROJECT.

MARY PROCTOR.

The first chapter in the story of the Cawthron Solar Observatory, which is to be erected in Nelson, New Zealand, in the near future, dates back to 1880, when Mr. Thomas Cawthron heard some lecture on astronomy given in Nelson by my father the late Richard A. Proctor. From that time he became interested in the wonders of southern skies, and hoped that the day would come when he might be able to furnish the necessary amount for the erection of an observatory in Nelson. Since 1880, vast strides have been made in our knowledge of the sun, and the widespread appreciation of the importance of its study is illustrated by the formation in recent years of the International Union for Coöperation in Solar Research, which counts among its members astronomers and physicists in many parts of the world. The Solar Union has already obtained favourable results through this coöperation, and many more may be expected in the future.

Several problems connected with the sun depend for their solution upon a continuous series of observations made throughout the twenty-four hours, during which the earth rotates once about her axis and presents different parts of her surface in succession to the sun. At present, there are Solar Observatories at Yerkes and Mount Wilson in America, Cambridge and Meudon in Europe, and Kodaikanal in India, but a great gap existed between the observatories in California and India, extending over a distance of 150 degrees, or nearly half the earth's circumference. The establishment of a Solar Observatory to fill in the gap was essential for completing the chain of solar observatories round the world; and the project assumed an international importance. The location of the new station in Nelson, New Zealand, means that this most necessary link in the chain of Solar Observatories will be within the Empire, and that all four—the British, Indian, American, and New Zealand observatories, will be under the direction of English-speaking peoples.

The second chapter of the story, concerns the invitation to Sir Robert Ball to lecture in Australia and New Zealand in 1912, but he was unable to accept owing to ill health. He kindly suggested that I should go in his place, and pleased at an opportunity for doing something in behalf of the cause, I gladly accepted. After lecturing for some months in Australia, I went to New Zealand where I found the astronomical sec-

tion of the New Zealand Philosophical Society, keenly interested in the proposed Solar Observatory scheme. They arranged a course of lectures for me throughout the Dominion, but as it was then the summer season in New Zealand, I arranged to visit the Solar Observatory at Kodaikanal in India returning in time for the first lecture to be given the latter part of March. The attendance at my lectures gave ample proof of the interest taken in the project, but matters reached a climax when on April 14, 1913, I lectured in Nelson, and met Mr. Thomas Cawthron of that city.

A letter he had written to me in December (1912) on the occasion of my first brief visit to New Zealand, in which he asked for further details regarding the proposed Solar Observatory in Australasia, failed to reach me, so that I was quite unaware of his desire at that time to promote the undertaking. When I arrived in Nelson, the day before the lecture, I found a pretty little city, nestling amid mountain ranges and snowclad peaks. It is so peaceful and quiet, that it is usually referred to as Sleepy Hollow, but it was wide awake when the opportunity came for taking its part in the advancement of science. On the afternoon of my lecture at Nelson, I was introduced to Mr. Cawthron, and after telling him about the work in which I was so deeply interested, viz., that of arousing interest in the erection of a Solar Physics Observatory in New Zealand for the purpose of filling in the gap which at present existed in the chain of such observatories round the world, he told me that he was willing to provide the necessary funds for the undertaking.

The third chapter of my story is of the utmost importance, since it deals with the splendid gift made by Mr. Cawthron for the establishment of a Solar Physics Observatory at Nelson. Mr. Cawthron was born at Camberwell, England, in 1833, and received good educational training at Hoxton School, near his home. His father decided to emigrate to New Zealand with his family, and they arrived in Nelson in 1840. Before long, Mr. Cawthron crossed over to Australia and had some interesting experiences as a mining contractor at Ballarat and Bendigo. Returning to Nelson in 1857, he first of all took up mining contracts at the Dunn mountain copper mines, and elsewhere. Soon he was offered an agency in a shipping company, and for the next thirty years he was closely connected with almost all the shipping trade of the port of Nelson. During these years he was also engaged in business on his own account, and amassed a considerable fortune. He has been a generous benefactor to the city of Nelson, and many of its institutions are deeply indebted for the large donations they have received from him. Quite recently he presented a handsome organ to the School of Music, Cawthron Park for the entertainment of the people, the sum of

£15,000 for the Nelson Hospital, and now, as a climax to his benefactions, he has made the erection of a Solar Observatory in New Zealand an accomplished fact.

The fourth chapter of my story deals with the invitation of Mr. John Evershed, Director of the Solar Observatory at Kodaikanal, by the New Zealand Government, to visit Nelson for the purpose of advising Mr. Cawthron with regard to the selection of a suitable site for the Observatory. Mr. Evershed arrived in New Zealand on January 7 and at once proceeded to Nelson, where after making the necessary tests he expressed himself as highly gratified with the results. The question in New Zealand is not so much the duration of sunshine available, for fortunately bright days are the rule rather than the exception. But for this kind of work the air must be clear and above all it must be as steady as possible, for air currents whether caused by wind or the rising of hot air, are a fatal objection. The test applied at Nelson consisted merely of observing the sun under high magnifying power, with telescopes of three or four inches aperture, and studying the definition. It was necessary to consider the height at which the disturbances took place, and to this end one of the telescopes began its career of usefulness at sea level, viz., on the Boulder Bank. After that, the same telescope was carried to the top of the "Fringe", 2600 feet above the sea, and later on to a still higher peak at an altitude of 3500 feet, while a similar instrument was in constant use at the camp where the altitude was rather more than 2000 feet.

These hills and several others which were visited, are situated within six or seven miles of the city. They are easily reached and are thickly covered with beautiful native bush. This is a matter of some importance, for when the ground is well shaded by trees, the soil and rocks do not become heated by the sun, and the air above them remains cooler and steadier than it would in more exposed country. In testing, marks were given to the results by a system devised for the purpose, and this was afterwards found to be most convenient in another way. When the observers were stationed on different peaks, they could communicate their values to one another by heliographing with small mirrors. For instance, five flashes indicated "perfect", the number graduating down to one flash, which meant "poor", and practically out of the question. It was interesting to find how the atmospheric conditions differed at places not more than a couple of miles apart, and it soon became evident that there were peculiar local influences affecting the definition at different points. However, the suitability of Nelson as a site for a Solar Observatory was proved beyond a doubt, and the final chapter of my story remains to be told, when the Cawthron Solar Observatory is completed and the work in connection with the sun is in progress.

A SUMMARY OF THE ASTRONOMISCHE GESELLSCHAFT CATALOG.

LOUISE F. JENKINS.

The following table was prepared to give a general view of the catalogue, and to facilitate a comparison of the different zones.

The stars between $+80°$ and the pole were catalogued by Carrington before the Astronomische Gesellschaft Catalog was planned, and it was thought unnecessary to duplicate that work. The zone $-18°$ to $-22°$ is now being compiled at the observatory in Algiers, while the observatory at Cordoba will soon publish the zones $-22°$ to $-37°$. No definite plans have been made south of this limit. The observatory at Dorpat was assigned the zone $+70°$ to $+75°$ but was unable to complete it, and in 1905 Berlin undertook that work in addition to the two zones already completed there. For most zones the work was carried on by several persons, but in one instance, the Nicolajew zone, the entire work of the catalogue was performed by one individual.

It should be noted that the star positions in the different zones are not referred to the same equinox. That between $+70°$ and $+75°$ is referred to the equinox of 1905; the other zones north of $-2°$, to 1875; and south of $-2°$, to 1900.

The observing program for the catalogue consists of all stars in the Bonn Durchmusterung of magnitude 9.0 or brighter, all stars to which a letter of identification other than B is attached, and all B stars of magnitude 9.2 or brighter.

The zones usually overlap $20'$, though in several cases it is more, in one case $67'$, so that the average duplicated region between the zones is $26'$. The total number of stars for the whole catalogue therefore includes roughly 15,000 duplicates. Allowing for this about 163,000 stars were observed, and the number of observations in each coördinate is approximately 475,000.

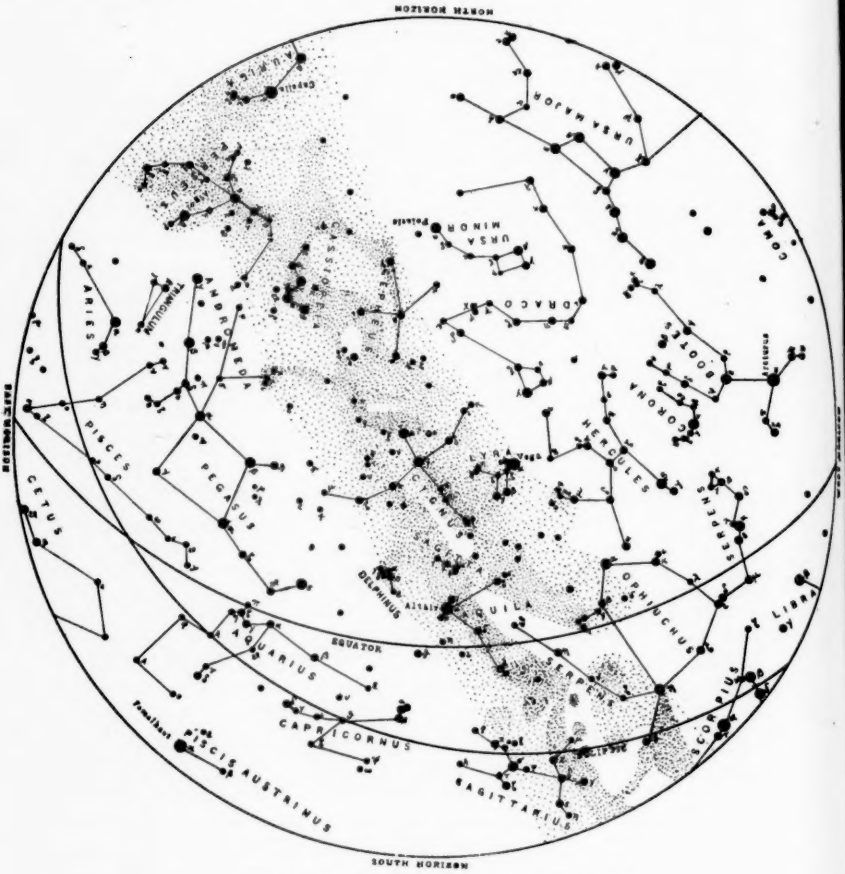
The probable errors here given were determined by comparing observations of the same star on successive nights, and not by comparisons with other catalogues. The Leipzig II zone, $+5°$ to $+10°$, was observed and compiled at the same time as the Leipzig I zone, $+10°$ to $+15°$, and therefore the probable errors were assumed to be the same as those given in the latter.

Zone Limits		Observatory	Date of Observations	Date of Publication	Number of Stars	Average No. of observations of a star	Probable Error one observation in R. A. (arc of a great circle)	Probable Error one observation in Decl.
							″	″
+75°	to +80°	Kasan	1869–1892	1898	4281	4.4	±0.60	±0.80
+70	+75	Berlin (C)	1905–1908	1910	3461	2.3	.19	.35
+65	+70	Christiania	1870–1881	1890	3949	2.9	.47	.82
+55	+65	Helsingfors	1869–1876	1890	14680	2.2	.76	.51
		Gotha	1877–1880				.94	.76
+50	+55	Cambridge. Mass.	1870–1884	1892	8627	3.1	.49	.55
+40	+50	Bonn	1869–1891	1894	18457	2.7	.88	.77
+35	+40	Lund	1879–1882, 1892–1895	1902	11446	2.7	.43	.32
+30	+35	Leiden	1870–1876, 1880–1898	1902	10239	2.2	.54	.48
+25	+30	Cambridge, England	1872–1896	1897	14464	3.5	.88	.51
+20	+25	Berlin (B)	1879–1883	1895	9208	2.7	.28	.30
+15	+20	Berlin (A)	1869–1874	1896	9789	2.5	.50	.47
+10	+15	Leipzig (I)	1868–1872	1900	9547	2.7	.57	.49
+ 5	+10	Leipzig (II)	1883–1893	1899	11875	2.4	.57	.49
+ 1	+ 5	Albany	1878–1882	1890	8241	2.5	.54	.55
+ 1	− 2	Nicolajew	1876–1899	1900	5954	2.3	.59	.69
− 2	− 6	Strassburg	1888–1895, 1903–1905	1906	8204	3.0	.52	.46
− 6	−10	Wien	1892–1902	1904	8468	2.2	.45	.47
		Ottakring						
−10	−14	Cambridge, Mass.	1888–1898	1912	8337	3.1	.80	.82
−14	−18	Washington	1894–1905	1908	8824	2.2	.72	.53

Allegheny Observatory.
April 10, 1914.

PLANET NOTES FOR SEPTEMBER AND OCTOBER, 1914.

The course of the sun during these two months lies in a southeasterly direction. The sun will be on the equator on September 23. Because of the rapid motion of the sun southward the days in the northern hemisphere will become shortened rapidly. The long polar night will begin on September 23, when the sun passes south of the equator.



THE CONSTELLATIONS AT 9:00 P. M. SEPTEMBER 1.

The phases of the moon for these months are as follows:

Full Moon	Sept.	4	at 8 A.M.	C. S. T.
Last Quarter		12	" 12 M.	"
New Moon		19	" 4 P.M.	"
First Quarter		26	" 6 A.M.	"

Full Moon	Oct.	3	at 12 P.M.	C. S. T.
Last Quarter		12	" 4 A.M.	"
New Moon		19	" 1 A.M.	"
First Quarter		25	" 5 P.M.	"

Mercury will be almost directly behind the sun on September 1. It will be moving eastward and by October 15 will reach a point of greatest eastern elongation. Near this date it will be visible in the southwest just after sunset. It will be found a few degrees south of the sun. It will set about one hour after the sun. It will not be very bright at this time and therefore not very conspicuous.

Venus will be the conspicuously brilliant evening star during this period. It will reach its farthest point east of the sun on September 18. At this time it will be quite high in the western sky at sunset. It will set about two and a half hours after the sun. It will have its greatest brilliancy on October 23. At this time it will be nearly ten times as bright as Sirius, the brightest star in the sky, and about one hundred times as bright as Aldebaran, the well known first magnitude star. At the beginning of this period it will be near Spica, the bright star in the constellation Virgo, and at the end it will be near Antares, the bright star in Scorpio.

Mars will move eastward just rapidly enough to keep ahead of the sun, but will be too near the horizon at sunset for favorable observation. At the beginning of September it will still be visible. Mars will be receding from the earth during this period and will reach its maximum distance about the end of October. It will then be approximately 230,000,000 miles away. At the beginning of this period, when still visible, it will be only as bright as Polaris, the north pole star, and will be distinguishable from the stars only by its ruddy color.

Jupiter will be the most favorably situated of the planets during these two months. It will be moving westward until October 12, which motion combined with the sun's motion eastward will make it rise considerably earlier from day to day. On September 1 it will cross the meridian about ten thirty at night, and on October 31 about six thirty. It will be found in the constellation Capricornus. It will be receding from the earth. It will be considerably brighter than Sirius.

Saturn will be coming into good position in the morning sky. At the beginning of this period it will cross the meridian a little after sunrise, and by the end it will cross at three thirty in the morning. It therefore will be within reach of early morning observations.

Uranus will be rather near to Jupiter in the sky during this period. It will therefore be in favorable position for observers during these two months.

Neptune will be visible in the morning sky during this period. By the end of October it will rise a little before midnight. It will be found in the constellation Cancer.

Occultations Visible at Washington.

Date 1914	Star's Name	Magnitude	IMMERSION. Washington M.T. h	m	Angle f'm N. °	EMERSION. Washington M.T. h	m	Angle f'm N. °	Duration h	m
Sept. 3	σ Aquarii	4.9	6	14	123	6	48	185	0	34
3	213 B Aquarii	6.5	15	40	81	16	38	211	0	58
4	316 B Aquarii	6.5	9	35	66	10	53	216	1	18
9	ϵ Arietis	4.6	7	51	77	8	41	239	0	50
12	406 B Tauri	5.6	13	54	95	15	4	246	1	10
14	κ Geminorum	3.7	14	9	153	14	40	217	0	31
Oct. 1	82 Aquarii	6.4	5	55	127	6	21	169	0	26
6	μ Arietis	5.7	6	8	52	6	58	260	0	50
7	18 Tauri	5.6	13	42	75	15	14	241	1	32
14	α Leonis	1.3	15	35	99	16	37	312	1	3
25	36 B Capricorni	6.2	8	46	81	9	50	220	1	5
26	30 Capricorni	5.4	7	3	358	7	47	295	0	44

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME

1914	h	m		1914	h	m	
Sept. 1	12	29	I Oc. Dis.	Sept. 13	10	36	II Tr. In.
2	9	36	I Tr. In.		12	14	II Sh. In.
	10	10	I Sh. In.		9	18	II Ec. Re.
	11	56	I Tr. Eg.	16	8	50	III Sh. Eg.
	12	31	I Sh. Eg.	17	10	28	I Oc. Dis.
3	6	55	I Oc. Dis.	18	7	35	I Tr. In.
	9	49	I Ec. Re.		8	30	I Sh. In.
4	6	23	I Tr. Eg.		9	56	I Tr. Eg.
	7	0	I Sh. Eg.		10	50	I Sh. Eg.
	12	40	IV Oc. Dis.	19	8	8	I Ec. Re.
5	8	40	III Oc. Dis.	21	8	43	IV Oc. Re.
6	8	17	II Tr. In.	22	7	3	II Oc. Dis.
	9	38	II Sh. In.	23	8	51	III Tr. Eg.
	11	13	II Tr. Eg.		9	10	III Sh. In.
	12	34	II Sh. Eg.	24	5	5	II Tr. Eg.
8	6	41	II Ec. Re.		7	5	II Sh. Eg.
9	11	22	I Tr. In.		12	16	I Oc. Dis.
	12	6	I Sh. In.	25	9	24	I Tr. In.
10	8	41	I Oc. Dis.		10	25	I Sh. In.
	11	44	I Ec. Re.		11	44	I Tr. Eg.
11	6	34	I Sh. In.	26	6	43	I Oc. Dis.
	8	9	I Tr. Eg.		10	4	I Ec. Re.
	8	55	I Sh. Eg.	27	6	11	I Tr. Eg.
12	6	13	I Ec. Re.		7	14	I Sh. Eg.
	12	4	III Oc. Dis.	29	9	26	II Oc. Dis.
13	9	19	IV Sh. Eg.	30	8	43	III Tr. In.

1914	h	m		1914	h	m	
Oct. 1	4	34	II Tr. In.	Oct. 16	9	38	IV Tr. Eg.
	6	46	II Sh. In.	17	9	7	II Ec. Re.
	7	30	II Tr. Eg.	18	6	14	III Oc. Dis.
	9	43	II Sh. Eg.		9	24	I Tr. In.
2	11	13	I Tr. In.		9	56	III Ec. Re.
3	8	33	I Oc. Dis.		10	41	I Sh. In.
4	5	40	I Tr. In.	19	4	13	II Sh. Eg.
	6	49	I Sh. In.		6	43	I Oc. Dis.
	6	59	III Ec. Re.		11	18	I Ec. Re.
	8	1	I Tr. Eg.	20	5	10	I Sh. In.
	9	10	I Sh. Eg.		6	12	I Tr. Eg.
5	6	28	I Ec. Re.		8	30	I Sh. Eg.
8	6	59	II Tr. In.	22	4	56	III Sh. Eg.
	7	2	IV Ec. Dis.	24	6	9	II Oc. Dis.
	9	22	II Sh. In.	25	5	55	IV Oc. Re.
	9	55	II Tr. Eg.		10	5	III Oc. Dis.
10	6	29	II Ec. Re.	26	3	53	II Sh. In.
	10	23	I Oc. Dis.		4	12	II Tr. Eg.
11	6	9	III Oc. Re.		6	49	III Sh. Eg.
11	7	29	III Ec. Dis.		8	36	I Oc. Dis.
11	7	32	I Tr. In.	27	5	46	I Tr. In.
	8	45	I Sh. In.		7	6	I Sh. In.
	9	52	I Tr. Eg.		8	6	I Tr. Eg.
	11	0	III Ec. Re.		9	26	I Sh. Eg.
	11	5	I Sh. Eg.	28	6	42	I Ec. Re.
12	8	23	I Ec. Re.	29	5	18	III Sh. In.
13	5	34	I Sh. Eg.		8	58	III Sh. Eg.
15	9	28	II Tr. In.	31	8	46	II Oc. Dis.

Note:—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on July 1, 1914.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900 h m	Decl. 1900 ° ′	Magn.
U Cassiop.	0 40.8	+47 43	12.1*d*	S Cor. Bor.	15 17.3	+31 44	10.4*d*
X Cassiop.	1 49.8	+58 46	<11.0	RS Librae	18.5	−22 33	8.0 *i*
W Persei	2 43.2	+56 34	9.4	RU Librae	27.7	−14 59	10.7 *i*
X Camelop.	4 32.6	+74 56	12.6*d*	S Urs. Min.	33.4	+78 58	9.3 *i*
X Aurigae	6 4.4	+50 15	12.0*d*	X Cor. Bor.	45.2	+36 35	9.1 *i*
U Lyncis	31.8	+59 57	10.0	R Serpentis	46.1	+15 26	8.2*d*
S Lyncis	35.9	+58 0	11.0*d*	V Cor. Bor.	46.0	+39 52	10.2*d*
S Can. Min.	7 27.3	+ 8 32	10.3*d*	RZ Scorpii	58.6	−23 50	9.4
U Cancri	8 30.0	+19 14	12.4	R Herculis	16 1.7	+18 38	9.1*d*
T Cancri	51.0	+20 14	9.0	U Serpentis	2.5	+10 12	12.6*d*
W Cancri	9 4.0	+25 39	8.4*d*	RU Herculis	6.0	+25 20	13.0*d*
R Leo. Min.	39.6	+34 58	11.2	W Cor. Bor.	11.8	+38 3	11.2 *i*
R Leonis	42.2	+11 54	10.2*d*	U Herculis	21.4	+19 7	9.4*d*
V Leonis	54.5	+21 44	9.5*d*	SS Herculis	28.0	+ 7 3	11.2*d*
R Urs. Maj.	10 37.6	+69 18	9.2*d*	W Herculis	31.7	+37 32	12.2 *i*
W Leonis	48.4	+14 15	<12.0	R Urs. Min.	31.3	+72 28	9.3
R Com. Ber.	11 59.1	+19 20	8.0	R Draconis	32.4	+66 58	11.5*d*
SU Virginis	12 0.0	+12 56	11.0 *i*	S Draconis	40.8	+55 7	8.8
T Virginis	9.5	− 5 29	11.4*d*	RR Ophiuchi	43.2	−19 17	9.7 *i*
R Corvi	14.4	−18 42	6.9	S Herculis	47.4	+15 7	8.0 *i*
SS Virginis	20.1	+ 1 19	8.2*d*	RR Scorpii	50.2	−30 25	6.4
T Can. Ven.	25.2	+32 3	11.4	RV Herculis	56.8	+31 22	10.7 *i*
Y Virginis	28.7	− 3 52	13.0*d*	R Ophiuchi	17 2.0	−15 58	9.7 *i*
T Urs. Maj.	31.8	+60 2	10.0*d*	RT Herculis	6.8	+27 11	<13.0
R Virginis	33.4	+ 7 32	7.0	Z Ophiuchi	14.5	+ 1 37	8.5*d*
RS Urs. Maj.	34.4	+59 2	8.3	RS Herculis	17.5	+23 1	9.5 *i*
S Urs. Maj.	39.6	+61 38	11.2	RU Ophiuchi	28.5	+ 9 30	<13.0
RU Virginis	42.2	+ 4 42	9.6	T Draconis	54.8	+58 14	9.5 *i*
U Virginis	46.0	+ 6 6	9.5	RY Herculis	55.4	+19 29	13.6*d*
V Virginis	13 22.6	− 2 39	11.6*d*	T Herculis	18 5.3	+31 0	12.8*d*
R Hydrae	24.2	−22 46	6.8*d*	W Draconis	5.4	+65 56	10.0
S Virginis	27.8	− 6 41	12.4	RY Ophiuchi	11.6	+ 3 40	12.2
T Urs. Min.	32.6	+73 56	<13.0	W Lyrae	11.5	+36 38	7.9
T Centauri	36.0	−33 6	6.8	X Ophiuchi	39.6	+ 8 44	8.7
R Can. Ven.	44.6	+40 2	9.1	R Scuti	42.2	− 5 49	5.6
Z Bootis	14 1.7	+13 59	10.2*d*	R Aquilae	19 1.6	+ 8 5	11.4*d*
Z Virginis	5.0	−12 50	<13.0	V Lyrae	5.2	+29 30	12.2*d*
U Urs. Min.	15.1	+67 15	11.0*d*	X Lyrae	9.0	+26 36	8.9
S Bootis	19.5	+54 16	11.6*d*	R Sagittarii	10.8	−19 29	8.4*d*
RS Virginis	22.3	+ 5 8	7.8	TZ Cygni	13.4	+50 0	11.2
V Bootis	25.7	+39 18	7.8	U Lyrae	16.6	+37 42	11.2*d*
R Camelop.	25.1	+84 17	12.2*d*	TY Cygni	29.8	+28 6	10.5*d*
R Bootis	32.8	+27 10	10.4 *i*	RT Aquilae	33.3	+11 30	10.4*i*
U Bootis	49.7	+18 6	10.8	R Cygni	34.1	+49 58	9.3*d*
RT Librae	15 0.8	−18 21	<12.0	TT Cygni	37.1	+32 23	7.9
Y Librae	6.4	− 5 38	11.0 *i*	RT Cygni	40.8	+48 32	11.9
S Librae	15.6	−20 2	8.4 *i*	TU Cygni	43.3	+48 49	<12.0
S Serpentis	17.0	+14 40	10.8	X Aquilae	46.5	+ 4 13	8.4

Approximate Magnitudes of Variable Stars of Long Period on July 1, 1914.—Continued.

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900.	Dec. 1900.	Magn.
	h m	° ′			h m	° ′	
χ Cygni	19 46.7	+32 40	<12.0	RW Cygni	20 25.2	+39 39	8.8
SY Aquilae	20 2.3	+12 39	11.4	R Vulpeculae	59.9	+23 26	8.0
S Cygni	3.4	+57 42	<11.0	T Cephei	21 8.2	+68 5	8.4 *i*
SV Cygni	6.5	+47 35	9.1	W Cygni	32.2	+44 56	6.0
S Aquilae	7.0	+15 19	9.6	RU Cygni	37.3	+53 52	8.8
RS Cygni	9.8	+38 28	8.7	RV Cygni	39.1	+37 34	7.4
RT Capricorni	11.3	−21 38	7.8	V Cassiop.	23 7.4	+59 8	8.8 *i*
U Cygni	16.5	+47 35	7.4 *i*				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign < that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. L. Baldwin, H. C. Bancroft, Jr., T. C. H. Bouton, N. Bruseth, H. O. Eaton, E. Gray, S. H. Huntington, S. C. Hunter, J. B. Lacchini, F. C. Leonard, C. B. Lindsley, O. Mach, C. Y. McAteer, W. T. Olcott, E. W. Putnam, C. Richter, F. H. Spinney, H. M. Swartz, H. W. Vrooman, I. E. Woods, and A. S. Young.

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and May E. Abbott at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1914 Sept.-Oct.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7	22 13			28 3				
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	1 24;	18 7;	4 13;	20 20				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	12 6;	27 17;	13 4;	28 15				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	1 17;	16 12;	1 7;	16 2				
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	1 3;	17 0;	2 21;	18 19				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	2 10;	18 0;	3 14;	19 5				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	9 1;	23 14;	8 4;	22 18				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	9	25	11	27				
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	9 6;	26 11;	13 15;	30 18				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	3 4;	25 10;	6 13;	28 20				
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	9 1;	20 16;	2 7;	25 13				
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	4 14;	19 21;	5 5;	20 12				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	1 19;	22 1;	2 5;	22 11				
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	7 8;	22 18;	8 4;	23 15				
RZ Gemin.	5 56.6	+22 12	9.1—10.0	5 12.7	10 3;	21 5;	7 19;	24 9				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	9 17;	24 20;	9 23;	25 2				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	8 12		5 12					
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	6 21;	21 7;	5 16;	20 2				
W Gemin.	6 29.2	+15 24	6.7— 7.5	7 22.0	6 20;	22 16;	8 12;	24 8				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	2 3;	22 10;	2 14;	22 21				
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	5 12;	27 18;	20 1					
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	6 23;	22 20;	8 18;	24 15				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	6 21;	20 6;	10 8;	23 17				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	9 17;	28 6;	7 13;	26 2				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	13 3;	30 14;	9 8;	26 20				

Maxima of Variable Stars of Short Period.—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1914. Sept.-Oct.
	h m	° ′		d h	d h d h d h d h d h
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0	15
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	6 5; 19 18; 3 8; 23 17
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	7 23; 21 4; 10 23; 24 4
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	3 4; 22 11; 11 19; 31 2
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	7 12; 23 11; 9 10; 25 9
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	11 4; 24 15; 8 2; 21 13
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	10 6; 21 22; 9 9; 21 1
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	11 11; 25 13; 9 14; 23 16
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	17 21; 5 4; 22 10
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	12 5; 28 14; 15 0; 31 10
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	12 23; 27 0; 11 1; 25 2
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	8 16; 25 2; 11 13; 27 23
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	11 15; 22 14; 9 2; 25 13
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 23; 18 1; 3 3; 18 5
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	10 3; 24 23; 9 19; 24 15
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	14 9; 27 22; 11 11; 25 1
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	9 10; 22 1; 11 0; 23 16
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	7 14; 27 2; 6 20; 26 8
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	7 20; 25 13; 13 6; 30 23
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	9 1; 21 4; 3 7; 21 11
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7 23; 22 0; 6 1; 20 1
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	11 16; 28 19; 15 22
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	9 9; 24 14; 9 18; 24 23
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	12 6; 23 19; 11 3; 22 16
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	8 20; 22 8; 5 19; 19 7
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	7 15; 28 8; 8 16; 29 9
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	11 1; 23 2; 11 5; 23 6
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	13 0; 25 6; 7 13; 25 22
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	11 17; 23 14; 11 10; 23 8
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	8 8; 26 12; 5 14; 23 19
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	14 2; 28 3; 12 4; 26 5
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	9 9; 23 9; 7 9; 21 9
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	8 19; 24 18; 10 17; 26 10
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	2 21; 18 6; 3 15; 19 1
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	12 22; 27 6; 11 15; 25 23
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	8 14; 25 8; 12 3; 28 21
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	7 11; 26 10; 9 1; 28 0
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	6 10; 22 19; 9 4; 25 14
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	7 11; 20 18; 4 1; 21 19
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	12 7; 25 18; 9 5; 22 16
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	12 19; 26 5; 9 16; 23 2
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	9 18; 24 11; 9 4; 23 22
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	3 4; 18 21; 4 14; 20 8
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	13 2; 26 21; 10 16; 24 10
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	7 17; 22 7; 11 18; 21 11
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	8 0; 25 8; 12 15; 29 22
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	8 16; 24 19; 10 21; 21 15
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	3 11; 25 5; 6 2; 27 20
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	9 3; 22 0; 11 6; 24 2
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	7 20; 22 19; 7 18; 22 17
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	11 18; 22 15; 8 23; 25 7
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	10 12; 23 3; 12 0; 24 14
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	14 7; 26 10; 8 13; 20 17
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	6 23; 21 22; 6 21; 26 20

Minima of Variable Stars of Short Period.

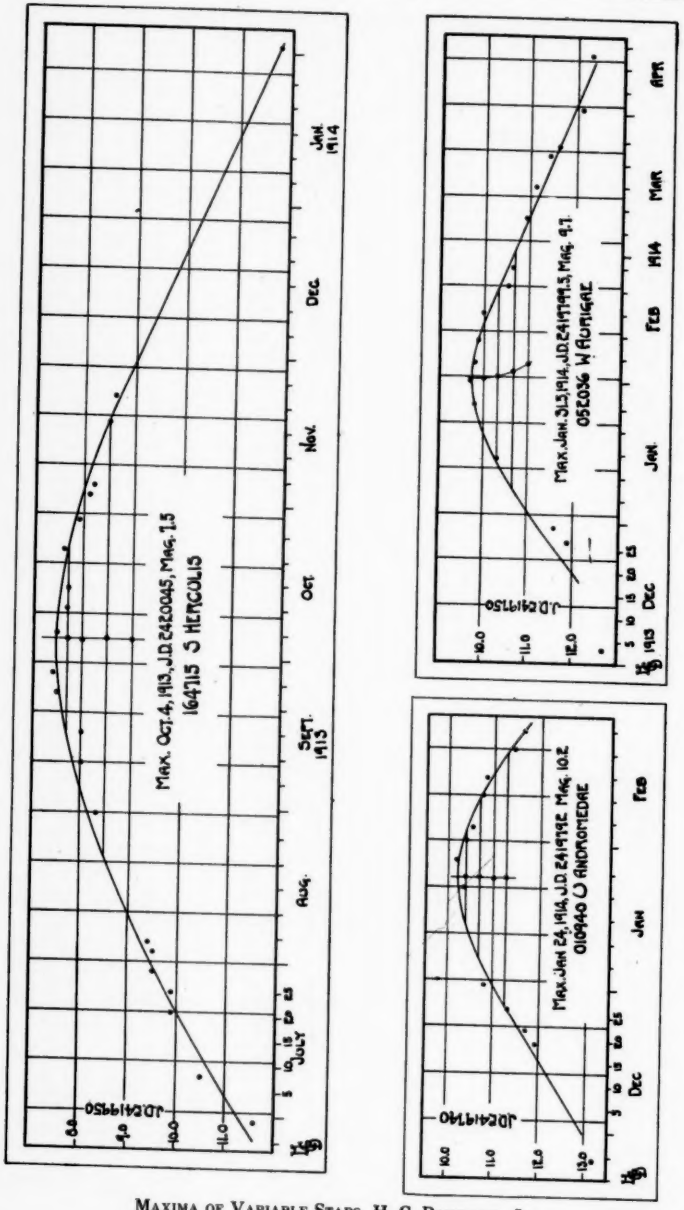
[Calculated by May E. Abbott, at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1914 Sept.-Oct.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	3 15				8 13			
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	5 17;	21 1;			6 10;	21 18		
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	8 14;	23 11;			8 7;	23 4		
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	8 15;	23 14;			8 13;	23 12		
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	10 13;	22 19;	11 3;	23 8				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	7 13;	21 20;	6 3;	20 9				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	9 15;	23 8;	7 1;	20 19				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	8 5;	22 13;	6 21;	21 5				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	11 7;	28 20;	7 15;	25 4				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	2 13;	18 10;	4 8;	20 5				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	11 5		13 13					
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	7 9;	24 14;	6 2;	23 6				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	7 14;	21 5;	4 19;	25 4				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	8 3;	23 22;	9 18;	25 13				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	6 16;	23 6;	9 21;	26 12				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	6 0;	21 19;	7 14;	23 9				
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	11 16;	24 21;	8 2;	21 6				
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	4 4;	23 2;	11 23;	30 20				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	6 2;	30 23;	13 9;	25 19				
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	9 7;	22 15;	5 23;	19 7				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	10 2;	21 0;	1 22;	23 18				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	6 16;	24 17;	12 19;	30 18				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	6 5;	23 13;	10 21;	28 5				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	1 18;	22 14;	2 23;	23 19				
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	9 11;	25 12;	11 13;	27 13				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	9 21;	21 8;	8 13;	20 0				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	7 0;	23 19;	10 15;	27 10				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	5 19;	22 5;	8 14;	25 0				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	11 6;	26 12;	11 18;	27 0				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	11 6;	23 11;	5 16;	30 2				
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	13 22;	28 6;	12 14;	26 23				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	7 12;	25 17;	4 19;	22 23				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	10 23;	29 13;	8 20;	27 11				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	6 3;	25 23;	5 21;	25 17				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	10 0;	26 20;	13 15;	30 10				
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	8 14;	21 11;	10 18;	23 15				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	12 5;	26 19;	11 8;	25 21				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	12 7;	28 12;	6 15;	22 21				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	11 3;	30 2;	9 14;	28 13				
RX Hydrae	9 0.8	− 7 52	9.1—10.5	2 6.8	4 19;	23 1;	11 7;	29 13				
S Antliae	27.9	−28 11	6.3— 6.8	0 07.8	12 19;	25 18;	8 18;	21 16				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	9 3;	26 22;	8 19;	26 14				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	13 21;	30 18;	9 4;	26 1				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	5 14;	24 3;	12 16;	30 5				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	9 17;	22 22;	6 3;	19 8				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	9 0;	26 14;	14 5;	31 19				
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	11 2;	25 18;	10 10;	25 1				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	8 1;	21 15;	5 4;	18 18				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	13 0;	28 0;	13 0;	28 1				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	10 3;	25 0;	9 4;	24 18				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	11 16;	25 15;	9 14;	23 13				
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	10 15;	24 10;	8 5;	22 1				
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	3 22;	20 18;	7 14;	24 10				
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	13 10;	28 18;	14 1;	29 9				

Minima of Variable Stars of Short Period.—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean time of minima in 1914 Sept.-Oct.							
	h m	° ′		d h	d	h	d	h	d	h	d	h
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	11	2;	25	19;	10	11;	25	3
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	8	6;	24	18;	11	6;	27	18
R Arae	31.1	—56 48	6.8— 7.9	4 10.2	3	16;	21	9;	9	2;	26	19
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	9	0;	29	18;	9	11;	30	5
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	10	16;	24	7;	7	21;	21	12
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	9	1;	25	20;	4	5;	21	0
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	10	4;	22	11;	10	22;	23	6
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	11	15;	26	1;	10	11;	24	21
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	11	19;	26	13;	11	7;	26	1
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	9	0;	25	9;	11	18;	28	2
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	10	15;	25	17;	10	19;	25	21
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	13	3;	28	15;	14	2;	29	14
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	13	2;	29	2;	15	1;	31	0
WX Sagittae	53.6	—17 24	9.2—10.8	2 03.1	6	1;	23	2;	10	3;	27	3
WY Sagittae	17 54.9	—23 1	9.5—10.6	4 16.0	11	1;	29	17;	9	1;	27	17
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	2	22;	23	14;	3	22;	24	14
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	9	23;	24	11;	8	23;	23	10
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	14	18;	28	13;	12	9;	26	4
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	4	21;	20	0;	5	4;	20	7
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	8	16;	25	5;	11	18;	28	6
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	6	11;	24	6;	12	1;	29	20
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	6	13;	23	3;	9	18;	26	9
RR Draconis	40.8	+62 34	9.3—13	2 19.9	13	24;	22	11;	9	11;	26	11
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	10	22;	24	4;	7	11;	20	18
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	3	8;	29	3;	12	1;	24	23
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	2	18;	21	20;	10	23;	30	1
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	13	12;	28	16;	13	19;	28	23
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	11	7;	25	17;	10	2;	24	12
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	6	12;	24	10;	12	7;	30	5
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	9	22;	23	11;	6	23;	20	12
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	10	18;	25	11;	10	5;	24	22
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	7	7;	23	0;	8	18;	24	12
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	8	19;	21	21;	11	10;	24	11
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	10	20;	22	20;	10	20;	22	21
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	9	7;	22	13;	5	20;	19	2
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	8	7;	26	14;	5	18;	24	1
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	2	8;	18	4;	6	1;	22	22
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	13	22;	27	12;	11	2;	24	15
UW Cygni	19.6	+42 55	10.5—13	3 10.8	14	16;	28	11;	12	6;	26	1
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	3	8			11	3		
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	8	20;	28	1;	7	16;	26	22
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	5	21;	24	6;	12	16;	31	1
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	8	20;	23	20;	8	19;	23	19
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	7	18;	19	11;	6	23;	24	12
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	2	5;	22	10;	12	14;	22	17
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	11	4;	25	22;	10	17;	25	11
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	9	15;	29	0;	8	17;	28	2
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	9	15;	25	9;	11	2;	26	20
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3					2	1		
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2	3;	22	10;	2	14;	22	21
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	7	23;	23	12;	9	1;	24	15
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	8	9;	24	17;	11	0;	27	8
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	8	8;	24	22;	11	12;	28	3
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	9	5;	24	7;	9	8;	24	10
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	9	6;	25	18;	12	5;	28	17



MAXIMA OF VARIABLE STARS, H. C. BANCROFT, JR.

New Variable Stars.—A new variable 20.1914 Cancri is announced in *A.N.* 4733, having been discovered by by Mme. L. Ceraski. The position of the star is given for 1900.0 as $\alpha = 8^h\ 8^m\ 44^s.30$, $\delta = +25°\ 2'\ 16.''8$. From 22 plates taken in the interval 1905-1913, the variation is determined as from $8^m.8$ to $9^m.9$.

In *A. N.* 4733 the new variable 21.1914 Aurigae also is announced. This star is in position for 1900.0, $\alpha = 6^h\ 2^m\ 24^s$, $\delta = +\ 46°\ 35.'4$. This variable was discovered by R. Furuhjelm at Helsingfors. Its variation seems to be from $11^m.5$ to $<12^m.0$.

In *A. N.* 4738 three new variables are announced by J. H. Metcalf having been discovered by him on plates taken by the 12-inch doublet. They are as follows:

		α (1900.0)	δ (1900.0)
1.	22.1914 Leonis	$10^h\ 28^m\ 22^s.6$	$+12°\ 1.1$
2.	23.1914 Leonis	10 18 35 .5	+10 15.3
3.	24.1914 Leonis	10 34 24 .4	+ 9 31.2

These stars are all rather faint having a variation in the neighborhood of 12^m to 14^m. The determinations, however, are given as only approximate.

Two other new variables 25.1914 Herculis and 26.1914 Lyrae are announced in *A.N.* 4738 by C. R. D'Esterre. The first of these is in position for 1900.0, $\alpha = 18^h\ 2^m.6$, $\delta = +\ 39°\ 8'.7$. It seems to have a rather large range, from $11^m.5$ to $<16^m.0$. A period of 285 days for it fits the observations very satisfactorily. The second of these is BD $+41°$ 3021 ($9^m.4$). This star has a smaller range, from $10^m.35$ to $11^m.05$, and its period is short, probably very near three days.

The Recent Maximum of the Variable 154615 R Serpentis.—A few notes relative to the recent maximum of the long period variable 154615 R Serpentis may be of interest.

This variable was discovered by Harding in 1826. Its range is 5.4-7.6—13.0 with a mean period of 357.6 days. A study of its observed magnitude at maxima, as revealed by the data published in H. A. Vol. LV, Part II, reveals that, in the fifty-six years 1852 to 1908 inclusive, the variable reached fifth magnitude only five times.

The late maximum was approximately 5.8, the brightest since 1908, a maximum confirmed by members or the V.S.S. of the B.A.A. Thus we have a complete record of the maxima of this variable for a period of sixty-two years. The recorded maxima where the variable exceeded the sixth magnitude are as follows:—

Year	Magnitude
1852	5.4
1865	5.7
1870	5.6
1897	5.5
1900	5.7
1914	5.8

This table reveals the following interesting results as respects the intervals in years between bright maxima. These intervals are respectively: 13, 5, 27, 3, 14 years. Here we note a thirteen year interval followed by a short period of five years, followed by an interval approximately twice the length of the first period, then a short period followed by one similar approximately to the first of the series. This may be a coincidence; at any rate, it will be of interest to note whether we will observe another bright maximum of this variable in the years 1917-1919, as we might expect from a perusal of these data.

W. T. O.

COMET AND ASTEROID NOTES.

Comet *a* 1914 (Kritzinger).—This comet will be in such a position in the sky as to be visible to northern observers during the rest of the summer. It was never very bright and at present is becoming fainter rapidly and consequently will be visible only in the large telescopes. An ephemeris of this comet, taken from the *Lick Observatory Bulletin* No. 256 is given below. It is not extended beyond the last of August because of the extreme faintness of the comet.

The ephemeris is as follows:

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1914	True α	True δ	log Δ	Br.
	h m s	° ′ ″		
Aug. 3.5	22 45 18.8	+38 01 10	9.8696	0.46
4.5	45 23.2	37 39 24		
5.5	45 25.5	37 17 05		
6.5	45 25.8	36 54 14		
7.5	45 24.2	30 52	9.8761	0.42
8.5	45 20.8	30 06 59		
9.5	45 15.5	35 42 35		
10.5	45 08.7	35 17 42		
11.5	45 00.4	34 52 19	9.8832	0.39
12.5	44 50.7	26 26		
13.5	44 39.7	34 00 05		
14.5	44 27.6	33 33 17		
15.5	44 14.2	33 06 03	9.8913	0.36
16.5	43 59.8	32 38 24		
17.5	43 44.5	32 10 20		
18.5	43 28.4	31 41 54		
19.5	43 11.6	31 13 06	9.9004	0.33
20.5	42 54.2	30 43 56		
21.5	42 36.2	30 14 25		
22.5	41 17.8	29 43 36		
23.5	41 59.1	29 14 32	9.9107	0.30
24.5	41 40.2	28 44 13		
25.5	41 21.2	28 13 39		
26.5	41 02.3	27 42 54		
27.5	40 43.4	27 12 00	9.9223	0.27
28.5	40 24.6	26 40 57		
29.5	40 06.0	26 00 46		
30.5	39 47.8	25 38 30		
31.5	22 39 29.9	+25 07 10	9.9353	0.24

Brightness April 20 = 1.00.

SOPHIA H. LEVY.
C. D. SHANE.

Comet *b* 1914 (Zlatinsky).—This comet which was quite bright at the time of its discovery has diminished greatly in brightness. It has also moved so far south as to be out of reach for northern observers. During the months of August and September it will also be in nearly the same right ascension as the sun, and will be invisible for this reason also. In the latter part of August it will have only one four-thousandths of its brightness at the time of discovery.

Comet *c* 1914 (Neujmin).—This new comet was discovered on June 27 by Neujmin at Simeis. At first this object was not fully recognized as a comet but later it was observed at several different places and its identity as a new comet established. The elements of its orbit were computed by Professor Crawford Berkeley, California, as follows:

$T = 1914$, August 10.65 G.M.T.
$\omega = 16° 16'$
$\Omega = 270 18$
$i = 70 57$
$q = 3.740$

It is visible only in large telescopes and is now becoming fainter. The latest date for which an ephemeris is at hand is August 4.5, when its position is given from the above elements as follows: R.A. $= 17^h 34^m 06^s$, Dec. $= -5° 33'$.

Comet *f* 1913 (Delavan).—This comet will doubtless be an interesting object during the next few months. The Harvard College Observatory Bulletin No. 554 states that it was observed by Mr. John R. Hooper of Baltimore in the morning sky on June 30. It was described by him as hazy, about 5′ in diameter, with no visible nucleus. It was seen at the Goodsell Observatory on the morning of July 8. On this date it was readily found from the ephemeris and was bright enough to be seen in the 16-inch well into the dawn. On this date in the large telescope there was a well defined nucleus. Clouds and the absence of any bright star in the dawn prevented a measure of its position, but from the circles it seemed to be in almost the exact position assigned by the ephemeris published in the *Lick Observatory Bulletin*. No. 255. In this Bulletin revised parabolic elements are given as follows

$T = 1914$ Oct. 26.3108 Gr. M. T.
$\omega = 97° 26' 36''.7$
$\Omega = 59 11 48 .3$ } 1914.0
$i = 68 02 56 .6$
$q = 1.10501$

Elements for a hyperbolic orbit also were obtained and published in the same Bulletin, but a recent letter from Professor Leuschner states that the ephemeris obtained from the parabolic elements represents the recently observed places better than the hyperbolic solution. During August the comet will be found in the morning sky by the following ephemeris, and in September it may be bright enough to be found without an ephemeris.

EPHEMERIS FOR GREENWICH MEAN MIANIGHT.

1914	True α h m s	True δ ° ′ ″	log Δ	Br.
Aug. 6.5	6 21 55.6	+40 43 41	0.3576	12.25
8.5	28 56.4	41 24 43		
10.5	36 16.2	42 05 50	0.3430	
12.5	43 56.4	42 46 56		
14.5	6 51 58.4	43 27 49	0.3282	
16.5	7 00 23.6	44 08 21		
18.5	09 13.4	44 48 18	0.3133	
20.5	18 29.4	45 27 26		
22.5	28 12.9	46 05 29	0.2985	
24.5	38 25.1	46 42 07		
26.5	7 49 07.4	47 17 00	0.2838	
28.5	8 00 20.7	47 49 43		
30.5	8 12 05.6	+48 19 48	0.2695	35.41

Brightness 1914 March 1 = 1.00.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers. May, June, July 1914.—The length of a double report necessitates brief comment. It is a pleasure to welcome as members of the Association the following observers:

Mr. A. T. Bolfing, "Bg" Hayward, Cal. 4½″.

Mr. Harry L. Baldwin, "Bl" Washington, D. C. 9″ Reflector.

Mr. F. H. Spinney, "Sp" Hudson, N. H. 5″.

Mr. Carlos S. Mundt, "Mu" Alameda, Cal. 2⅛″.

Mr. Nels Bruseth has moved from Silvana, Wash., to Los Angeles, Cal. On his way south he called on a number of our observers in California.

Mr. Charles B. Lindsley, a recent addition to our ranks, deservers credit for two exceptionally good lists, 96 observations for May-June, and 109 for June-July.

Messrs. Bancroft and Lacchini continue to contribute over 200 observations a month, and their early morning observations are especially valuable.

The thanks of the Association are due Messrs. Bancroft, Mills, Lindsley, and McAteer for blue prints for distribution. The latter and Mr. Putnam have recently published articles on variable star observing in a Pittsburg paper, and the "Scientific American", respectively. These set forth the interesting and valuable features of the work and make a strong appeal to telescopists to join our ranks.

The last maximum of 074922 U Geminorum, and two maxima of 213843 SS Cygni were observed by several of our members as recorded in this report.

The charts have recently been revised at the Harvard College Observatory. A number of clerical errors have been corrected of which our members have been apprised. Several cases have been reported where the designated values of comparison stars do not seem to accord with visual estimates. In such cases it seems advisable to treat such stars as variables and observe them for signs of variability.

Mr. Bancroft with 270 observations contributed the greatest number in the May-June report. Mr. Lacchini with 227 attained this distinction in June-July.

Among many points of interest in this report, the rise of the variable 123459 RS Urs. Maj. and 193311 RT Aquilae are specially worthy of note. In the case of the latter a variable with a period of 325 days we observed a rise of 2.5 magnitudes in 16 days, or a gain of 10 times in brightness in that time. This variable is on the neglected list and should be observed frequently.

The statement in the last report relative to the minimum of 070310 R Can. Min. needs slight modification. The recent minimum was as low as any ever recorded, and the lowest in many years. In 1868, and 1877, we find records that the variable reached the magnitude of 10.9 at minimum. The only approach to that figure in recent years is a minimum of 10.6 magnitude on February 11, 1905.

A reference to the late maximum of 154615 R Serpentis too long to be included in this report, will be found elsewhere in this issue. Every observer is urged to go over the reports carefully and check up his observations. Where there is a wide variance from a mean of several estimates on a certain date caution in identifying the variable is desirable. The best interest of the Association can be served by clearing up as soon as possible the many errors due to misidentification.

VARIABLE STAR OBSERVATIONS May, June and July 1914.

001755
T Cassiopeiæ

Mo.	Day	Est.	Obs.
5	9	9.7	Bb
6		11.4	M

001726
T Androm.

Mo.	Day	Est.	Obs.
6	20	11.0	Ly

001838
R Androm.

Mo.	Day	Est.	Obs.
6	20	9.5	Ly
	29	9.4	E

004047
U Cassiop.

Mo.	Day	Est.	Obs.
5	2	8.6	L
	22	9.5	L
6	2	10.2	L
	13	11.4	L
	17	11.5	L
	19	11.7	L
	22	11.9	L
	29	12.5	E

004132
RW Androm.

Mo.	Day	Est.	Obs.
6	29	10.1	E

004435
V Androm.

Mo.	Day	Est.	Obs.
5	31	11.0	Ba
6	29	9.6	E

004958
W Cassiop.

Mo.	Day	Est.	Obs.
6	16	8.9	Ba

014958
X Cassiop.

Mo.	Day	Est.	Obs.
5	9	10.2	Bb
	12	11.3	L
6	29	11.8	M

015354
U Persei

Mo.	Day	Est.	Obs.
6	20	8.9	Ly

024356
W Persei

Mo.	Day	Est.	Obs.
6	13	9.5	L
	19	9.3	Le
	20	9.6	Ly
	23	9.4	L
	29	9.4	M
7	1	9.5	Le

033362
U Camelop.

Mo.	Day	Est.	Obs.
5	16	7.4	Ba
	31	7.4	Ba

043208
RX Tauri

Mo.	Day	Est.	Obs.
5	23	11.7	Bb

043274
X Camelop.

Mo.	Day	Est.	Obs.
4	28	8.3	L
5	2	8.5	Ba
	3	8.4	L
	6	8.7	L
	12	9.0	L
	14	9.7	Ba
	16	9.8	Ba
	21	10.6	L
	29	11.2	L
6	11	12.0	L
	16	12.1	L
	19	12.3	L
	22	12.3	L

050953
R Aurigae

Mo.	Day	Est.	Obs.
5	2	9.5	Ba
	6	9.7	Ba
	14	10.5	Ba

052034
S Aurigæ

Mo.	Day	Est.	Obs.
4	28	10.3	L
5	6	10.0	L

054920
U Orionis

Mo.	Day	Est.	Obs.
4	27	7.5	L
5	1	7.2	L
	2	7.1	L
	6	6.4	L
	11	6.5	L

055353
Z Aurigae

Mo.	Day	Est.	Obs.
5	30	9.7	Y

060450
X Aurigae

Mo.	Day	Est.	Obs.
5	22	12.0	L
	28	11.5	L
6	11	11.8	L

061647
V Aurigae

Mo.	Day	Est.	Obs.
5	23	12.4	Y

063159
U Lyncis

Mo.	Day	Est.	Obs.
5	2	9.6	Ba
	6	9.8	Ba
	14	9.8	Ba
	18	9.8	Ba
	26	9.8	Ba
	30	9.6	Ba
6	11	9.9	Ba

063558
S Lyncis

Mo.	Day	Est.	Obs.
5	2	10.1	Ba
	6	10.0	Ba
	9	10.0	Bb
	14	10.2	Ba
	18	10.2	Ba
	26	10.5	Ba
	30	10.2	Ba
6	11	10.8	Ba

064030
X Geminorum

Mo.	Day	Est.	Obs.
5	6	8.4	Ba
	16	8.4	Ba
	22	8.4	L
	23	8.8	Y

064932
NOVA GEMIN.

Mo.	Day	Est.	Obs.
5	9	11.5	Bb
	14	11.5	L
	22	11.7	L

065208
X Monoc.

Mo.	Day	Est.	Obs.
4	28	8.6	L

065355
R Lyncis

Mo.	Day	Est.	Obs.
5	30	10.3	Y

070310
R Can. Min.

Mo.	Day	Est.	Obs.
5	1	10.6	L
	3	10.7	L
	6	10.3	Ba
	6	10.7	L
	11	10.1	L

072708
S Can. Min.

Mo.	Day	Est.	Obs.
4	25	9.3	R
5	1	9.5	L
	4	9.5	L
	6	9.3	B
	8	9.7	H
	9	8.8	Ly
	9	9.3	Bb
	11	9.6	R
	13	9.5	St
	15	9.3	Ly
	16	9.9	G
	23	9.6	Ly
6	1	9.8	Ly

074323
T Gemin.

Mo.	Day	Est.	Obs.
5	9	9.2	Bb
	15	9.3	O
	17	9.6	Hu
	23	9.2	Y

074922
U Gemin.

Mo.	Day	Est.	Obs.
5	12	9.4	L
	14	9.0	L
	14	9.5	Ba
	14	9.3	O
	15	9.5	Ba
	15	9.3	O
	15	9.5	Bb
	16	9.5	O
	16	9.6	Ba
	17	9.7	O
	18	10.0	Ba
	18	10.0	O
	20	9.5	L
	22	10.3	L
	23	12.2	Bb

081112
R Cancri

Mo.	Day	Est.	Obs.
5	2	9.8	Bu
	3	9.7	L
	6	10.2	Bu
	11	9.0	L
	14	8.8	Ba
	22	8.5	L
	28	8.3	L

081633
T Lyncis

Mo.	Day	Est.	Obs.
5	17	10.6	Hu
6	3	12.0	H

082405
RT Hydrae

Mo.	Day	Est.	Obs.
4	27	7.9	L
5	2	8.0	Bu
	3	8.0	L
	6	8.0	Bu
	12	8.1	L
	26	8.5	G

083019
U Cancri

Mo.	Day	Est.	Obs.
5	23	12.4	Y

084803
S Hydrae

Mo.	Day	Est.	Obs.
5	14	11.3	Ba
	15	12.2	Bb

085008
T Hydrae

Mo.	Day	Est.	Obs.
4	27	8.0	L
5	2	8.2	Bu
	3	7.9	L
	6	8.0	Bu
	12	7.8	L
	16	8.0	Ba
	20	7.9	L

085120
T Cancri

Mo.	Day	Est.	Obs.
4	30	9.0	L
5	2	8.6	Bu
	6	8.4	Bu
	6	9.2	L
	12	9.1	L
	16	8.2	Ba
	17	8.2	Hu
	22	9.1	L
6	11	9.0	L

090425
W Cancri

Mo.	Day	Est.	Obs.
5	2	8.4	Bu
	6	8.6	Bu
	14	8.0	Ba
	15	7.9	V
	15	8.3	Y
	15	8.4	O
	18	7.9	V
	20	8.3	V
	22	8.3	V
	23	8.0	Ba
	24	8.1	L
	25	8.3	V
	29	8.0	L
	30	7.9	Ba
	11	8.2	L
6	11	8.1	Ba
	16	8.3	Ba
	22	8.3	L

093014
X Hydrae

Mo.	Day	Est.	Obs.
5	2	11.4	Ba

093934
R Leo. Min.

Mo.	Day	Est.	Obs.
5	2	10.4	Bu
	2	10.1	Ba
	6	10.8	Bu
	11	10.4	Ly
	15	11.2	Ba
	16	10.4	E
	17	11.0	Hu
	20	10.5	Ly
	23	10.7	Ly
6	9	10.6	E
	9	11.0	Ly
	16	11.0	Ly

094211
R Leonis

Mo.	Day	Est.	Obs.
4	25	6.8	R
	27	7.7	L
5	1	7.0	R
	1	8.5	Ma
	2	8.6	Bu
	2	7.5	Ba
	2	7.5	R
	4	7.8	L

VARIABLE STAR OBSERVATIONS May, June and July 1914.—Continued.

R Leonis			R Leonis			R Urs. Maj.			R Urs. Maj.			115919 R Comae		
Mo	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.
	6	8.8	Bu		22	9.6	L	5	1	8.2	Ma	6	10	8.2	B
	9	8.8	Bb		23	10.2	R		2	7.7	L		11	8.4	Ba
	9	8.2	Ly						3	8.0	L		11	8.7	P
	11	7.6	R		*094622*				5	7.8	Ly		11	8.1	G
	12	8.8	C		Y Hydrae				5	8.3	Ma		12	7.7	R
	12	8.4	L	5	2	6.6	Ba		6	8.0	Bu		12	8.6	Ma
	13	9.0	St						6	7.8	Ba		13	8.3	S
	14	8.3	Ly		095421				8	8.1	M		13	8.1	L
	14	8.4	O		V Leonis				9	7.7	Ly		13	8.5	H
	14	8.1	Ba	5	2	10.6	Bu		9	7.7	Bb		14	7.7	R
	15	8.4	M		6	10.4	Bu		9	8.2	M		14	8.2	O
	16	8.7	G		15	10.6	Bb		11	8.1	R		14	8.5	M
	16	8.7	E		15	9.6	Y		11	7.7	L		15	8.6	R
	17	8.4	Le		15	9.7	V		14	8.1	M		15	8.5	Ba
	17	9.0	C		15	9.7	Ba		14	8.0	Ba		16	8.7	R
	17	9.0	St		17	9.5	O		14	8.0	O		17	8.3	Ly
	18	8.5	O		18	9.5	O		14	8.4	Ma		17	8.2	O
	19	8.9	Ma		18	9.6	V		15	8.2	M		17	8.6	M
	19	8.7	G		20	9.3	V		15	7.6	Ly		19	8.5	St
	19	9.5	C		21	9.4	Y		16	8.2	O		19	8.4	E
	21	8.7	L		22	9.2	V		17	8.2	M		20	8.7	R
	23	8.5	Ly		23	9.1	Ba		17	8.2	St		20	8.6	Ba
	23	8.8	O		23	9.5	O		18	8.0	Ba		20	8.0	Hu
	23	8.8	S		25	9.2	V		19	8.0	P		20	8.4	G
	23	8.4	H		29	9.5	O		19	7.5	Ly		20	8.2	O
	23	8.1	Ba		30	9.1	Ba		21	7.9	L		21	8.8	R
	23	9.6	R		30	9.4	G		22	8.2	M		21	8.8	H
	23	9.1	Bb	6	9	9.2	V		23	7.7	S		22	8.2	B
	24	9.2	St		10	9.1	B		23	7.6	Ly		22	8.2	L
	24	9.7	R		11	9.2	Ba		23	7.5	Hu		23	8.5	Ly
	25	9.2	St		16	9.2	V		23	8.0	R		23	9.2	R
	25	9.0	R		20	9.3	B		23	8.0	O		25	8.5	O
	25	8.8	G		25	9.4	B		23	8.2	H		26	8.3	G
	27	9.3	St						23	8.1	Ba		27	9.1	Ma
	28	8.9	L						24	8.2	St		29	9.0	Ba
	30	8.3	Ba		*103012*				24	8.0	R	7	8	9.4	O
6	1	8.5	Le		U Hydrae				25	8.3	R				
	1	8.7	Ly	4	27	5.0	L		25	8.2	M		*104620*		
	8	9.1	G	5	2	5.0	Bu		25	8.1	St		V Hydrae		
	8	9.8	R		3	5.3	L		27	8.2	M	4	28	6.5	L
	9	9.4	L		4	5.2	L		27	8.0	St	5	2	6.2	Bu
	9	8.9	Ly		6	5.2	Bu		28	7.9	L		2	6.5	Ba
	10	9.1	R		6	5.4	L		29	8.0	G		4	6.6	L
	11	9.1	Ba		11	5.2	L		29	7.9	O		6	6.4	Bu
	11	9.2	G		12	5.0	C		30	8.0	P		12	6.4	L
	12	9.1	R		12	5.2	L		30	8.3	Ma		16	6.7	Ba
	13	9.2	Br		17	5.7	C		30	8.2	Ba		22	6.6	L
	14	9.2	R		19	5.2	C		30	8.2	M		28	6.6	L
	14	9.4	L		21	5.2	L		30	7.7	Ly		30	6.4	G
	15	9.3	R		22	5.1	L	6	1	8.4	M		30	7.8	Y
	16	9.4	Ba		23	5.5	H		1	8.4	Ma	6	5	6.8	Bu
	16	9.2	Ly		24	5.2	L		3	7.8	H		10	6.2	G
	16	9.3	Le		28	4.9	L		4	7.9	Ly		*105517*		
	16	9.3	Br	6	9	5.2	G		5	7.4	Bu		R Crateris		
	18	9.4	H		11	5.3	G		6	8.1	O	5	30	8.8	G
	19	9.0	St		11	5.0	L		8	7.9	G	6	9	8.4	G
	20	9.5	G						8	7.9	R				
	20	9.8	R		103769				9	8.5	Ma		110506		
	22	9.3	B		R Urs. Maj.				10	7.8	R		S Leonis		
				4	28	7.9	L		10	8.2	O	5	30	10.3	Y

120012 SU Virginis			
Mo.	Day	Est.	Obs.
6	13	12.3	Ba
	17	10.8	G
	20	12.0	Ba
	120905		
	T Virginis		
5	2	9.5	Ba
	14	9.8	Ba
	15	10.3	V
	23	10.4	Ba
	26	10.4	V
	30	10.5	Ba
6	11	11.0	Ba
	20	11.3	Ba
	121418		
	R Corvi		
4	30	10.7	L
5	2	10.7	Ba
	11	10.8	L
	12	10.7	L
	14	10.6	L
	14	10.3	Ba
	14	10.3	B
	16	10.5	G
	17	10.0	Hu
	18	9.9	B
	22	9.6	L
	23	9.4	Ba
	25	9.4	G
	26	9.2	B
	28	9.3	L
	30	8.8	G
	30	8.8	Ba
	30	8.2	M
6	2	8.7	Y
	5	8.0	B
	8	7.8	G
	9	7.7	G
	9	8.0	L
	10	8.0	Hu
	10	7.6	G
	10	7.6	B
	11	7.8	Ba

VARIABLE STAR OBSERVATIONS May, June and July 1914—Continued.

R Corvi

Mo.	Day	Est.	Obs.
6	11	7.5	G
	12	7.5	G
	13	7.4	G
	14	7.5	L
	15	7.3	G
	16	7.3	G
	16	7.4	Ba
	17	7.1	B
	17	7.3	G
	18	7.5	L
	20	7.3	G
	20	7.1	Ba
	21	7.2	G
	22	7.0	B
	22	7.4	L
	25	7.2	L
	25	7.0	G
	26	7.0	G
	28	6.9	G
	29	6.9	G
	30	7.1	Ba

122001

SS Virginis

5	2	7.1	Ba
	2	7.8	Bu
	6	7.8	Bu
	9	7.9	Bb
	15	8.0	Ba
	17	8.0	Hu
	18	8.0	B
	23	7.9	Ba
	26	7.9	G
	28	7.1	B
	30	8.0	Ba
6	5	8.0	B
	5	8.4	Bu
	10	8.3	Hu
	11	7.8	Ba
	12	8.1	B
	12	8.1	G
	17	7.9	B
	20	8.1	Ba
	30	7.9	Ba

122532

T Can. Ven.

5	30	11.7	Y
	31	11.4	Ba
6	16	11.3	Ba

122803

Y Virginis

4	28	9.9	L
5	2	10.2	Ba
	14	11.0	L
	14	10.5	Ba
	15	10.5	Y
	21	10.8	L
	23	10.9	Ba
	24	10.8	L

Y Virginis

Mo.	Day	Est.	Obs.
5	29	10.9	L
	30	11.5	Ba
	30	11.3	Y
6	10	12.1	B
	11	12.2	Ba
	11	12.0	L
	20	12.8	B
	25	12.8	B

123160

T Urs. Maj.

5	1	7.8	Ma
	2	7.4	Bu
	2	7.6	Ba
	5	8.4	Ly
	6	7.4	Bu
	6	7.5	Ba
	9	8.2	M
	9	8.2	Ly
	9	7.6	Bb
	11	8.3	R
	14	8.1	E
	14	8.0	O
	14	7.6	Ba
	15	8.3	Ly
	15	8.3	M
	16	8.4	G
	17	7.9	Le
	18	7.9	Ba
	18	8.2	O
	18	8.4	M
	19	8.2	Ma
	19	8.5	P
	21	8.5	M
	21	8.6	Ly
	22	8.6	M
	23	8.3	Hu
	23	8.3	O
	23	8.2	Ba
	23	8.0	R
	24	8.0	R
	25	8.4	G
	25	8.5	R
	25	8.7	M
	27	8.8	M
	27	8.4	Br
	27	8.7	S
	28	8.5	Br
	29	8.6	O
	30	8.9	M
	30	8.5	Ma
	30	8.2	Ba
	30	8.6	P
6	1	8.4	Le
	1	8.4	Ma
	2	8.6	G
	4	8.9	Ly
	5	7.5	Bu
	9	8.7	E
	9	8.8	Ma

T Urs. Maj.

Mo.	Day	Est.	Obs.
6	10	8.9	Br
	10	9.0	O
	11	8.8	G
	11	8.8	S
	11	8.7	Ba
	12	8.9	Ma
	13	8.9	Br
	14	9.0	M
	14	9.1	O
	14	8.9	Sp
	15	9.1	Ba
	15	9.1	Br
	16	9.0	Le
	16	9.3	Br
	17	9.2	Ly
	17	9.2	M
	17	9.3	Bl
	17	9.1	O
	19	8.6	St
	20	9.4	Ba
	20	8.9	Hu
	22	9.4	O
	23	9.6	Ly
	25	9.8	O
	25	9.9	Bl
	27	9.8	Ma
	29	10.0	Bl
	29	9.8	Ba

123307

R Virginis

4	27	10.2	L
5	2	10.0	L
	2	10.2	Bu
	2	9.8	Ba
	3	9.7	Ly
	6	10.0	Bu
	9	10.1	Bb
	14	9 0	L
	14	9.0	O
	14	8.8	Ba
	17	8.3	Hu
	18	8.7	O
	18	8.7	E
	21	7.8	L
	23	7.9	Ba
	24	7.7	L
	25	7.7	S
	26	7.8	Ba
	26	8.1	G
	28	8.4	Ly
	29	7.5	L
	30	7.7	Ba
6	4	8.1	Ly
	5	7.5	B
	9	6.9	L
	10	7.7	Hu
	10	7.3	Ba
	11	7.3	Ba
	12	7.6	G
	13	8.0	H

R Virginis

Mo.	Day	Est.	Obs.
6	14	6.5	L
	14	7.8	Ly
	16	7.3	Ba
	16	7.7	S
	18	7.5	Ly
	18	6.9	L
	19	7.4	H
	20	6.5	H
	21	6.6	H
	22	6.4	H
	23	6.5	H
	23	6.9	L
	24	6.5	H
	28	6.6	H
	29	7.4	Ly
	29	7.2	G
	30	7.3	Ba

123459

RS Urs. Maj.

5	2	12.8	Ba
	14	12.0	Ba
	18	11.8	Ba
	23	11.6	Ba
	30	11.1	Ba
6	11	9.8	Ba
	15	9.2	Ba
	20	8.7	Ba

123961

S Urs. Maj.

4	28	8.5	L
5	1	8.7	Ma
	2	8.8	Bu
	2	8.5	Ba
	3	8.5	L
	5	8.6	Ly
	6	8.8	Bu
	6	8.5	Ba
	9	8.8	Bb
	9	8.7	Ly
	9	9.0	M
	11	8.9	R
	12	9.2	L
	12	9.1	C
	14	8.9	Ba
	14	9.0	E
	14	9.3	O
	14	9.3	Ma
	15	8.8	Ly
	15	9.2	M
	16	9.1	G
	17	9.4	C
	17	9.1	R
	17	9.5	Le
	18	9.5	M
	18	9.2	Ba
	18	9.4	O
	19	9.5	Ma
	19	9.1	G

S Urs. Maj.

Mo.	Day	Est.	Obs.
5	19	9.1	C
	21	9.1	Ly
	22	9.8	M
	23	9.5	L
	23	9.5	O
	23	9.4	Ba
	23	8.9	Hu
	24	9.2	R
	25	9.2	G
	25	9.4	R
	25	9.8	M
	27	10.1	Br
	27	9.9	M
	27	9.7	S
	28	10.1	Br
	29	9.7	O
	30	9.7	Ba
	30	10.3	M
	30	10.4	P
6	1	9.6	Le
	1	9.4	Ly
	2	9.6	G
	2	10.1	L
	5	9.4	Bu
	6	9.8	Ly
	9	10.1	E
	10	10.5	O
	10	10.5	Br
	11	10.4	Ba
	11	10.5	G
	12	10.2	L
	13	10.8	Br
	15	10.4	Ba
	15	10.9	Br
	15	11.0	Bl
	16	10.1	Le
	16	10.8	M
	16	10.8	Br
	17	11.0	O
	17	10.7	Bl
	17	10.4	L
	17	10.2	Ly
	20	10.7	Ba
	20	10.4	Hu
	22	11.3	L
	23	10.3	Ly
	25	11.0	O
	25	10.6	L
	29	11.0	Ba

124204

RU Virginis

5	9	11.6	Bb
	14	11.1	L
	14	11.0	Ba
	17	9.6	Hu
	20	11.2	L
	23	10.3	Ba
	24	11.0	L
	28	9.3	B

VARIABLE STAR OBSERVATIONS May, June and July 1914.—Continued.

RU Virginis

Mo.	Day	Est.	Obs.
5	29	10.7	L
	30	9.7	Ba
6	5	9.0	B
	10	9.6	Hu
	11	9.4	Ba
	11	10.2	L
	18	10.1	L
	20	9.4	Ba
	23	10.1	L
	30	9.6	Ba

124606

U Virginis

5	9	12.2	Bb
	14	10.9	L
	16	12.1	Ba
	17	10.4	Hu
	22	11.5	L
	23	11.7	Ba
	26	9.8	S
	28	10.8	B
	28	11.5	L
	30	11.3	Ba
6	5	11.4	B
	11	10.3	L
	11	10.5	Ba
	12	10.2	B
	16	9.8	S
	18	10.3	Ly
	18	10.0	L
	20	9.6	Ba
	23	9.7	L
	30	9.5	Ba

132002

W Virginis

5	28	10.2	G

132202

V Virginis

5	9	9.2	Bb
	15	9.5	Ba
	15	9.5	Y
	26	10.1	Ba
	28	10.0	B
	28	10.0	G
	31	10.5	Ba
6	5	10.2	B
	10	10.5	B
	11	10.5	Ba
	17	11.0	G
	20	11.6	B
	25	11.5	B

132422

R Hydrae

4	27	4.8	L
	29	4.9	L
5	2	5.0	Bu

R Hydrae

Mo.	Day	Est.	Obs.
5	4	5.1	L
	6	5.1	L
	6	5.2	Bu
	11	5.3	L
	14	6.4	Ma
	16	5.7	G
	19	5.8	G
	21	5.7	L
	24	5.9	L
	25	5.9	G
	26	6.0	G
	29	6.0	L
6	1	6.3	Ma
	5	6.4	Bu
	9	6.3	Ma
	9	5.9	L
	10	6.2	G
	13	6.4	G
	14	6.0	L
	17	6.5	G
	18	6.4	L
	21	6.6	G
	22	6.5	L
	26	6.7	G

132706

S Virginis

4	30	10.5	L
5	9	10.8	Bb
	11	10.4	Ly
	14	11.0	L
	15	10.6	Ly
	15	11.2	M
	16	11.3	Ba
	17	10.6	Hu
	23	10.8	Y
	23	10.7	Ly
	24	11.0	L
	28	11.5	G
	29	11.3	L
	30	11.8	Ba
	30	11.8	M
6	10	10.4	Hu
	11	11.9	Ba
	11	11.8	L
	13	11.9	H
	18	11.1	Ly
	20	12.0	Ba
	23	12.2	L

133273

T Urs. Min.

5	30	11.0	P

133633

T Centauri

5	17	6.7	C
	19	6.8	C
	28	7.2	G

T Centauri

Mo.	Day	Est.	Obs.
6	11	7.0	G
	13	6.9	G
	21	6.8	G
	25	6.7	G

134440

R Can. Ven.

5	2	7.0	Bu
	2	7.2	Ly
	2	7.3	L
	6	7.2	Bu
	6	8.0	Ba
	12	8.1	L
	14	8.1	Ba
	15	8.0	Ly
	15	8.1	M
	16	8.3	E
	19	8.5	P
	23	8.1	Hu
	23	8.3	L
	25	8.4	M
	26	8.5	Ba
	27	8.6	S
	30	8.5	Ba
	30	8.4	M
	30	8.4	Ly
	30	8.6	P
6	2	8.6	L
	5	8.0	Bu
	9	8.8	E
	10	8.6	Hu
	11	8.6	S
	11	8.6	Ba
	13	8.6	L
	14	8.6	O
	16	9.0	G
	16	8.4	M
	18	8.9	L
	18	8.9	Ly
	20	8.8	Ba
	20	8.8	S
	22	8.7	O
	22	9.0	L
	23	9.0	M
	25	9.0	L
	29	9.1	M
	30	8.9	Ba

140113

Z Böotis

5	16	12.2	Ba
	23	11.2	Ba
	23	10.7	Y
	30	10.2	Ba
6	11	9.8	Ba
	20	10.1	Ba
	30	10.2	Ba

141567

U Urs. Min.

5	3	8.8	Bu
	6	9.0	Bu

U Urs. Min.

Mo.	Day	Est.	Obs.
5	6	9.0	Ba
	14	9.2	Ba
	18	9.5	Ba
	23	9.7	Ba
	27	10.2	S
	30	9.7	Ba
6	5	10.2	Bu
	11	10.4	G
	11	10.2	Ba
	15	10.8	Ba
	16	10.5	S
	20	10.8	Ba
	25	10.1	Hu
	29	10.4	Ba

141954

S Böotis

4	25	8.8	R
5	3	9.3	L
	3	9.4	Bu
	5	9.9	H
	6	9.6	Bu
	6	9.6	Ba
	10	9.4	Ly
	12	9.6	L
	15	10.2	Ba
	16	9.6	G
	19	9.7	Ma
	22	10.3	E
	23	10.3	Ly
	23	10.0	L
	26	10.4	Ba
	26	10.1	M
	27	10.4	Br
	27	10.2	S
	28	10.4	Br
	30	10.6	Ly
6	2	10.7	L
	6	10.8	Bu
	10	10.7	Br
	11	11.0	Ba
	13	10.9	Br
	14	11.0	L
	16	10.8	M
	16	11.1	Ba
	16	11.0	Br
	16	10.6	E
	17	10.7	Ly
	19	11.2	L
	22	11.2	L
	23	10.9	Ly
	30	11.6	Ba

142205

RS Virginis

5	9	11.8	Bb
	14	10.1	L
	16	10.2	Ba
	21	9.7	L
	23	9.7	Ba

RS Virginis

Mo.	Day	Est.	Obs.
5	24	9.2	L
	29	9.3	L
	30	9.6	Ba
6	6	10.4	Bu
	9	8.5	L
	11	8.7	Ba
	16	8.2	L
	22	8.1	L
	25	7.9	L
7	2	7.8	Ba

142539

V Böotis

5	2	8.3	L
	2	7.7	Ba
	3	7.5	Bu
	5	8.5	H
	6	8.1	L
	6	7.8	B
	7	7.4	Bu
	10	7.9	Ly
	10	8.0	M
	12	8.3	L
	14	7.9	O
	14	8.1	Ma
	15	7.5	Ba
	16	7.2	G
	16	8.1	M
	18	7.9	O
	18	7.7	B
	18	7.7	Le
	19	7.5	G
	19	8.5	Ma
	19	7.2	P
	23	7.6	Ly
	23	7.3	Ba
	23	8.3	L
	25	8.2	M
	25	7.6	G
	27	7.8	Br
	27	8.6	S
	28	7.8	Br
	29	7.7	
	30	7.9	O
	30	7.5	Ba
	30	7.7	Ly
	30	7.0	P
6	1	8.1	Le
	2	7.9	L
	6	7.5	Bu
	8	7.7	G
	9	7.9	Ma
	10	7.8	Br
	11	7.6	G
	11	7.5	Ba
	11	8.2	Bl
	12	7.6	Sp
	13	7.8	Br
	13	7.8	Sp
	13	8.2	L

VARIABLE STAR OBSERVATIONS May, June and July 1914.—Continued.

V Boötis

Mo.	Day	Est.	Obs.
6	14	7.5	M
	15	7.9	Br
	16	7.9	Br
	16	8.0	Sp
	16	8.0	Le
	17	7.2	G
	17	7.4	M
	17	7.8	Sp
	17	8.2	L
	18	8.2	Ly
	19	8.2	L
	20	7.1	G
	20	8.5	S
	20	7.6	Ba
	22	7.9	O
	22	8.0	Sp
	23	8.2	Ly
	23	8.3	L
	25	7.1	G
	26	7.9	Hu
	27	7.8	Ma
	29	8.1	Bl
	30	7.7	Ba

142584
R Camelop.

Mo.	Day	Est.	Obs.
4	30	9.8	L
5	3	9.6	Bu
	4	10.2	L
	7	9.8	Bu
	10	10.0	Ly
	12	10.4	L
	16	10.8	G
	16	10.6	Ly
	18	11.0	Le
	23	11.0	L
	29	11.2	L
	30	11.2	Ba
6	1	11.5	Le
	6	11.0	Bu
	11	11.6	L
	16	11.8	Le
	17	11.4	Ly
	19	11.7	L
	19	12.7	E
	25	12.0	L

143227
R Boötis

Mo.	Day	Est.	Obs.
4	28	12.2	L
5	6	12.1	B
	14	12.3	L
	18	12.3	B
	24	12.6	L
	28	12.2	B
	31	12.0	Ba
6	11	11.7	L
	11	11.5	Ba
	13	11.5	Br
	16	11.5	M

R Boötis

Mo.	Day	Est.	Obs.
6	16	11.5	L
	19	11.1	L
	20	11.0	Ba
	20	11.3	S
	23	11.1	L
	26	10.3	Hu
	30	10.5	Ba

144918
U Boötis

Mo.	Day	Est.	Obs.
5	15	10.4	V
	15	10.9	Ba
	16	10.5	Y
	23	10.3	Ba
	23	10.4	Y
	25	10.3	V
	27	10.6	M
	30	10.2	Ba
	31	10.5	M
6	10	10.1	V
	11	10.3	Ba
	16	10.4	M
	19	10.3	V
	20	10.8	Ba
	30	10.8	Ba

150605
Y Librae

Mo.	Day	Est.	Obs.
5	22	11.9	L
6	14	12.2	L
	16	12.0	L
	22	11.5	L
	25	11.2	L

151520
S Librae

Mo.	Day	Est.	Obs.
	28	10.1	L
5	12	9.9	L
	15	9.8	Ly
	16	9.8	Ba
	16	9.5	Y
	20	9.6	Ly
	22	9.7	L
	23	9.5	Ly
	26	9.4	Ba
	26	9.5	Ly
	28	9.4	L
	31	9.4	Ba
6	2	9.1	Y
	6	8.4	Bu
	9	9.0	L
	9	9.1	Ly
	11	8.6	Ba
	14	8.6	L
	18	8.8	Ly
	20	8.5	Ba
	21	8.7	Ly
	22	8.6	L
	25	8.5	L
	28	8.6	Ly

151614
S Serpentis

Mo.	Day	Est.	Obs.
5	14	10.6	Ba
	23	10.6	Ba
	24	12.0	L
	26	11.0	G
	30	10.6	Ba
6	10	11.4	V
	13	10.7	L
	13	10.7	G
	13	10.5	Ba
	15	10.8	G
	17	10.6	M
	17	10.9	L
	19	11.1	V
	20	10.5	O
	23	10.9	L
	25	11,4	E

151731
S Cor. Bor.

Mo.	Day	Est.	Obs.
5	1	9.0	Ma
	3	8.8	Bu
	5	9.8	H
	6	8.8	B
	7	9.0	Bu
	11	9.2	R
	11	9.4	Ly
	14	9.9	O
	15	9.3	Ba
	16	9.5	Ma
	17	9.5	M
	18	9.5	B
	22	9.9	E
	23	10.0	Ba
	23	8.9	R
	24	8.9	R
	25	9.4	G
	25	8.9	R
	26	10.0	Ly
	27	10.2	M
	28	9.3	B
	30	9.9	Ba
6	6	9.4	Bu
	8	9.6	R
	10	9.5	G
	12	9.3	R
	13	10.2	Ba
	13	10.8	Br
	17	10.2	Sp
	17	10.2	Bl
	17	10.0	M
	18	10.4	Ly
	20	10.4	Ba
	22	10.3	Sp
	25	10.3	Sp
	25	10.4	Bl
	25	10.5	E
	26	10.5	Ly
	30	10.4	Ba

151822
RS Librae

Mo.	Day	Est.	Obs.
5	16	10.8	Ba
	22	10.0	L
	23	10.4	Ba
	28	10.0	L
	30	10.0	Ba
6	9	9.1	L
	11	8.7	Ba
	14	8.8	L
	16	8.0	Ba
	22	8.3	L
	25	8.0	L

152714
RU Librae

Mo.	Day	Est.	Obs.
5	31	13.2	Ba
6	9	11.4	L
	11	12.2	Ba
	14	11.6	L
	16	11.7	Ba
	22	11.4	L
	24	11.2	L
	30	10.7	Ba

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
4	28	10.8	L
5	3	10.4	Bu
	6	10.7	L
	6	10.3	Ba
	7	10.2	Bu
	14	10.2	Ba
	20	10.2	L
	23	10.1	L
	23	10.2	O
	23	10.0	Ba
	25	9.5	G
	30	9.9	Ba
	30	10.2	Ly
6	2	9.5	G
	9	9.6	L
	9	9.9	Ly
	10	9.6	Bu
	11	9.7	Ba
	11	9.5	G
	12	9.9	Sp
	14	10.0	Sp
	16	9.6	L
	18	10.0	Sp
	20	10.0	Ba
	20	9.7	Ly
	22	9.5	L
	22	9.6	Sp
	23	10.0	B
	25	8.9	Hu
	29	9.5	Ly
	30	9.3	Ba

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
4	29	6.0	L
5	1	6.0	Ma
	3	6.0	Bu
	3	5.8	Ly
	5	5.9	H
	5	5.8	Ma
	6	5.6	Ba
	6	6.0	L
	7	6.0	Bu
	8	6.2	H
	11	5.8	Ly
	11	6.0	R
	12	5.5	C
	12	5.9	L
	14	5.6	Ba
	14	6.0	O
	15	6.1	Bb
	15	5.6	Ba
	15	6.0	O
	16	6.0	G
	16	6.0	O
	16	5.6	Ba
	17	6.5	R
	17	5.9	Ly
	17	5.9	M
	17	5.6	C
	18	6.0	O
	18	6.0	J
	18	5.6	B
	18	5.7	La
	19	6.0	G
	19	6.2	P
	19	6.0	M
	19	5.4	Ca
	22	6.0	L
	22	6.3	H
	23	6.0	Bb
	23	5.6	Ba
	23	6.0	O
	23	6.2	R
	23	5.8	H
	23	5.5	Hu
	24	6.3	H
	24	6.4	R
	25	6.6	R
	25	6.0	G
	25	5.8	Ly
	26	5.6	Ba
	27	6.2	Br
	28	6.2	H
	28	6.2	Br
	29	6.0	O
	29	6.0	L
	30	6.0	J
	30	6.0	G
	30	6.0	O
	30	6.1	P
	30	5.6	Ba
	31	5.6	Ba

VARIABLE STAR OBSERVATIONS May, June and July 1914.—Continued.

161607

R Cor. Bor.				R Cor. Bor.				R Serpentis				X Herculis				W Ophiuchi			
Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est	Obs.	Mo.	Day	Est.	Obs
5	31	6.0	Ly	6	23	6.4	H	5	16	6.5	Ly	5	12	6.2	L	5	16	12.8	Ba
	32	6.0	Wn		23	6.0	L		16	6.3	Ba		23	6.8	H		30	12.9	Ba
6	1	6.1	Wn		24	6.0	O		16	6.6	G		28	6.9	H	6	15	13.4	Ba
	1	5.9	Ly		24	6.3	H		16	6.7	O	6	3	6.8	H				
	1	6.0	Ma		25	6.0	Bl		17	6.3	M		9	6.8	H		162112		
	2	6.0	G		25	6.0	L		18	6.7	O		10	6.4	H	V Ophiuchi			
	3	5.7	Le		25	6.0	O		23	6.9	O		12	6.2	H	5	17	8.6	Ba
	3	6.0	Ma		25	6.0	G		25	6.6	Ly		13	6.2	H		26	8.9	Ba
	4	6.0	Ly		26	6.0	Ly		25	6.8	G		19	6.4	H	6	10	10.2	Bu
	6	6.1	Bl		26	6.0	O		26	6.8	Ba		20	6.3	H		15	9.5	Bl
	8	6.2	H		26	6.0	Wn		29	7.1	O		21	6.4	H		15	8.0	Ba
	8	6.2	R		27	6.4	H		31	7.1	Ba		22	6.3	H				
	9	6.1	H		27	6.0	Ma		31	6.6	Ly		23	6.3	H		162119		
	9	6.0	Ly		28	6.4	H	6	6	7.4	O		24	6.4	H	U Herculis			
	9	6.0	Ma		28	5.9	Ly		9	6.8	G		27	6.4	H	5	1	8.3	Ma
	10	6.0	Wn		29	6.0	Bl		9	6.8	Ly		28	6.5	H		5	7.9	H
	10	6.0	O		29	6.0	Ly		10	7.2	Bu		29	6.5	H		5	8.2	Ly
	10	6.1	R		29	6.4	H		10	7.4	O						10	8.2	M
	10	6.2	H		30	5.6	Ba		10	7.8	R		160118				11	8.5	R
	10	5.8	G		30	5.9	J		11	7.4	Bl	R Herculis					11	8.2	Ly
	10	6.4	Bu	7	2	5.6	Ba		12	8.0	R	5	15	8.3	Ba		14	8.7	O
	11	6.0	Bl		8	6.0	O		13	7.3	G		23	8.0	Ba		15	8.4	Bb
	11	5.5	Hu						14	8.2	R		23	8.4	Y		16	7.5	G
	11	6.0	P		154536				14	7.7	O		30	7.9	Ba		17	8.5	M
	11	5.6	Ba	X Cor. Bor.					15	7.5	Ba	6	9	8.5	V		17	8.4	Ba
	11	5.9	G	5	15	10.8	Ba		15	8.0	R		15	8.4	Ba		17	9.0	O
	12	6.0	Ma		22	10.6	Ba		16	8.0	R		16	8.5	V		19	8.9	Ma
	12	6.3	H		29	11.0	G		16	8.4	M		20	9.0	Ba		23	9.0	O
	12	5.9	G		30	10.1	Ba		17	8.0	O		24	9.0	V		23	8.7	R
	13	6.1	H	6	11	9.7	Ba		17	7.3	Ly		30	9.1	Ba		24	8.8	R
	13	6.0	L		15	9.4	Ba		18	7.5	Ly						25	8.7	R
	13	5.6	Ba		20	9.2	Ba		19	7.2	St		160210				25	8.7	M
	14	6.0	O						20	7.9	Ba	U Serpentis					25	8.2	G
	15	5.9	G		154639				20	7.9	Ly	5	3	9.0	Bu		26	8.7	Ba
	15	5.6	Ba	V Cor. Bor.					20	8.0	R		7	9.0	Bu		26	8.5	Ly
	16	5.9	J	6	3	9.0	Bu		20	8.1	O		14	10.3	O		26	9.0	S
	16	6.0	G		7	9.2	Bu		21	7.8	R		16	10.5	Ba		29	9.1	O
	16	5.6	Ba		15	9.2	Ba		22	8.1	O		23	10.9	Ba		30	9.3	Y
	17	6.0	Bl		16	9.5	G		23	8.0	R		24	11.6	M		30	9.0	Ma
	17	6.0	Ly		23	9.0	Ba		24	8.0	O		30	11.5	E		30	8.7	G
	17	6.0	O		23	9.5	Bb		25	8.4	Bl		30	11.3	Ba		31	9.0	Ba
	17	5.7	Le		25	9.5	G		25	8.4	E		31	11.4	M	6	1	8.8	G
	17	5.9	M		30	9.5	O		26	8.2	O	6	13	11.5	G		8	9.0	G
	18	6.0	Ly		30	9.7	G		26	8.0	Ly		15	12.5	Ba		8	9.2	R
	18	6.0	O		30	9.2	Ba	7	2	8.2	Ba		16	12.5	E		9	9.0	Ly
	18	6.2	H	6	10	9.8	G						17	12.0	M		9	9.1	Ma
	19	6.0	L		10	10.6	Bu		*155823*				160625				10	9.5	O
	19	5.9	H		11	9.1	Hu		RZ Scorpii				RU Herculis				10	9.0	R
	20	5.6	Ba		15	9.6	Ba	5	25	9.5	G	5	15	12.0	Bb		11	9.3	Bl
	20	6.2	H		17	10.4	M	6	9	9.3	G		16	12.0	Ba		12	9.0	R
	20	6.0	G		20	10.0	Ba		12	9.3	G		23	12.2	Ba		12	9.3	H
	20	5.9	Ly						17	9.4	G		24	11.8	M		13	9.2	Br
	20	6.0	J		154615				21	9.4	G		30	12.4	Ba		13	8.9	G
	20	6.0	O	R Serpentis								6	15	12.7	Ba		14	9.5	O
	21	6.0	Ly	5	2	6.1	Ly		155847				161138				14	8.9	R
	21	6.2	H		3	6.0	Bu	X Herculis				W Cor. Bor.					15	9.0	Ba
	22	6.1	Ly		7	6.0	Bu	5	3	6.2	L	6	11	11.0	Hu		15	9.3	R
	22	6.0	O		12	6.4	Ly		5	7.1	H		15	12.0	Ba		16	9.3	S
	22	6.4	H		14	6.5	O		6	6.2	L		20	11.6	Ba		16	9.3	R
	23	6.0	Ly		15	6.5	O		8	7.3	H		29	11.2	E	7	2	11.2	Ba
												7	2	11.2	Ba		16	9.4	E

VARIABLE STAR OBSERVATIONS May, June and July 1914—Continued.

U Herculis

Mo.	Day	Est.	Obs.
6	17	9.1	Sp
	17	9.6	M
	20	9.1	R
	21	9.4	R
	23	9.8	B
	23	9.3	R
	27	9.5	Ma
	29	9.2	Ly
	30	9.2	Ba

162807
SS Herculis

4	26	9.8	L
	28	9.8	L
5	2	9.4	L
	6	8.9	L
	11	8.9	L
	14	8.9	L
	16	9.2	V
	17	8.7	Ba
	21	8.9	L
	23	8.9	L
	23	9.0	Y
	25	9.2	V
	26	9.2	Ba
	29	9.0	L
	30	9.3	Ba
6	10	9.2	V
	10	9.6	O
	10	9.7	L
	13	9.0	G
	14	9.8	L
	14	9.8	O
	15	9.7	Ba
	17	9.9	L
	19	10.0	V
	20	10.1	Ba
	20	10.0	O
	22	10.6	L
	24	10.9	L
	25	10.7	O
	30	11.2	Ba

162816
S Ophiuchi

5	30	9.6	Ba
6	10	8.7	G
	15	9.6	Ba
	15	8.6	G

163137
W Herculis

5	15	12.6	Bb
	27	10.7	M
	30	12.6	Hu
6	11	11.2	Bu
	15	13.0	Ba
7	2	12.2	Ba

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
5	3	10.2	Bu
	7	10.4	Bu
	15	11.1	Bb
	18	9.6	Ba
	26	9.5	Ba
	27	9.5	M
	30	9.0	Ba
6	15	9.3	Ba
	30	9.3	Ba

163266
R Draconis

5	1	7.9	Ma
	3	8.0	Bu
	6	8.2	Ba
	7	8.2	Bu
	8	8.2	M
	9	8.2	M
	14	8.6	O
	14	8.3	M
	15	8.4	Bb
	16	8.4	Ly
	17	8.5	M
	18	8.7	Ba
	18	8.9	O
	18	8.5	Le
	19	8 8	Ma
	21	8.8	Ly
	22	8.8	M
	24	9.3	O
	26	8.8	S
	26	8.9	Ba
	27	9.1	M
	29	9.4	O
	29	9.0	G
	31	9.1	Ba
6	1	9.4	Le
	1	9.2	Ma
	2	9.8	Y
	6	9.8	O
	9	9.5	Ly
	9	9.9	Ma
	10	9.8	O
	10	10.0	Bu
	11	10.2	Ba
	16	10.5	G
	16	10.3	M
	16	9.7	S
	16	9.7	Ly
	17	10.6	Sp
	17	10.9	Le
	18	10.7	Sp
	20	10.9	Ba
	25	10.8	Sp
7	2	11.5	Ba

164055
S Draconis

5	25	8.3	G
	27	8.7	M

S Draconis

Mo.	Day	Est.	Obs.
6	9	8.4	G
	13	8.5	G
	16	8.8	M

164319
RR Ophiuchi

5	30	11.3	Ba
6	9	10.4	H
	15	9.7	Ba
	24	9.9	H

164715
S Herculis

5	11	10.5	Ly
	11	10.3	M
	15	10.0	Bb
	15	9.6	O
	17	9.6	Ba
	17	10.2	M
	21	9.7	Ly
	23	9.5	O
	23	9.3	Ba
	28	9.3	Ly
	29	9.4	O
	31	9.0	Ba
6	2	9.2	Y
	2	9.0	G
	10	8.9	Ly
	10	9.2	O
	10	9.8	Bu
	11	8.6	Ba
	13	8.9	Br
	17	8.8	O
	20	8.4	Ba
	20	8.2	Ly
	25	8.3	O
	26	8.5	G
	29	8.1	Ly
7	2	8.0	Ba

164844
RS Scorpii

6	26	11.4	G

165030
RR Scorpii

6	9	6.3	G
	10	6.3	G
	12	6.4	G
	20	6.4	G

165631
RV Herculis

5	5	12.0	H
	14	22.2	E
	17	13.4	Ba
	22	12.1	L
	26	12.1	Ba
	30	11.5	E
	30	11.9	M
	31	11.8	Ba

RV Herculis

Mo.	Day	Est.	Obs.
6	2	11.8	Y
	2	11.7	L
	11	11.2	L
	11	10.9	Ba
	11	10.8	Hu
	13	10.8	G
	14	10.5	M
	15	11.2	M
	16	10.3	M
	16	10.8	L
	19	10.9	L
	20	10.9	Ba
	23	10.8	L
	24	10.9	H
7	2	10.7	Ba

170215
R Ophiuchi

5	17	12.0	Ba
	22	11.0	M
	31	11.6	Ba
6	9	10.7	G
	9	9.8	H
	11	11.1	Ba
	15	10.6	G
	20	10.8	H
	21	11.0	H
	21	10.5	G
	24	10.7	H
7	2	9.7	Ba

171332
W Herculis

6	16	4.6	R
	20	4.7	R
	23	4.4	R

171401
Z Ophiuchi

5	22	7.8	V
	26	8.2	Ba
	31	8.2	Ba
6	9	8.0	G
	10	8.4	V
	13	7.7	G
	15	7.9	G
	16	8.7	Ba
	19	8.4	V
	21	7.9	G
	22	8.5	O
	26	8.4	O
7	2	8.5	Ba

171723
RS Herculis

5	17	12.8	Ba
	23	12.4	Y
	26	12.2	Ba
	30	12.4	Y
	31	12.2	Ba

RS Herculis

Mo.	Day	Est.	Obs.
6	11	11.2	L
	12	10.5	B
	12	10.6	V
	15	10.3	Ba
	16	10.1	L
	19	9.9	L
	19	9.8	V
	23	9.8	L
7	2	9.5	Ba

172808
RU Ophiuchi

5	17	13.1	Ba

174406
RS Ophiuchi

6	15	11.0	G

175458
T Draconis

5	16	10.5	O
	16	10.9	V
	18	11.1	Ba
	21	10.1	M
	23	10.1	Y
	25	10.0	G
	26	10.9	V
	30	10.1	O
	31	10.0	Ba
6	1	9.8	E
	10	10.1	O
	11	10.0	Ba
	12	10.6	V
	16	10.0	M
	16	9.9	G
	19	10.6	V
7	2	9.5	Ba

175519
RY Herculis

5	15	11.1	Bb
6	12	13.1	B
	25	13.5	E

180531
T Herculis

4	28	8.0	L
5	1	8.2	Ma
	2	8.2	L
	11	9.3	Ly
	12	8.6	C
	12	8.9	L
	14	9.5	Ly
	14	8.9	Ma
	15	9.2	O
	16	9.7	G
	17	9.4	M
	17	9.5	O
	17	8.9	C
	19	9.7	Ma
	21	9.7	Ly

VARIABLE STAR OBSERVATIONS May, June and July, 1914.—Continued.

T Herculis

Mo.	Day	Est.	Obs.
5	21	9.5	L
	23	9.6	O
	24	10.4	L
	25	9.9	G
	26	10.0	Ba
	28	9.8	Ly
	28	11.3	H
	29	10.5	O
	29	10.8	L
	31	10.5	Ba
6	2	10.5	G
	9	11.2	H
	9	10.0	Ly
	11	11.9	Hu
	11	12.2	L
	11	10.5	Bl
	16	12.2	Ba
	16	12.4	L
	19	12.4	L
	20	9.8	H
	24	10.0	H
	25	12.6	L
	29	10.1	Ly

180565
W Draconis

5	31	11.9	Ba
6	11	11.4	Ba
	16	11.0	Ba
7	2	11.0	Ba

181103
RY Ophiuchi

6	16	12.2	Ba

181136
W Lyrae

5	7	10.8	M
	11	10.3	M
	16	10.0	E
	16	9.7	O
	16	9.8	G
	17	9.5	Ba
	17	9.9	M
	18	9.3	Le
	19	9.8	M
	21	9.4	M
	22	9.3	M
	23	9.4	O
	25	9.2	M
	25	8.5	G
	26	9.0	Ba
	27	9.1	M
	29	9.3	O
	30	9.0	M
	31	8.6	Ba
6	1	8.8	Le
	2	8.4	G
	10	8.3	G
	10	8.6	O
	11	8.2	Hu
	11	8.3	Ba
	12	8.3	R

W Lyrae

Mo.	Day	Est.	Obs.
6	13	8.4	G
	14	8.2	M
	14	8.3	O
	15	8.3	R
	16	8.2	G
	16	8.3	E
	16	8.4	R
	17	8.1	M
	17	8.5	Le
	18	8.0	O
	19	8.2	Bl
	20	8.3	G
	20	8.3	R
	20	8.2	P
	21	8.5	R
	23	8.4	R
	24	8.0	O
	25	8.1	B
	25	8.1	G
7	2	7,9	Ba

183308
X Ophiuchi

4	28	8.5	L
5	6	8.6	L
	15	8.8	Ma
	18	8.8	Ba
	22	8.5	L
	28	8.8	G
	30	9.1	Ly
	30	8.6	Ma
	31	8.5	Ba
6	6	8.9	Ly
	12	8.9	Ma
	12	8.6	H
	13	8.4	L
	16	8.8	Ba
	17	9.4	Bl
	17	9.1	O
	17	8.5	Sp
	18	8.9	Sp
	19	8.5	L
	21	8.7	Ly
	21	8.1	G
	24	8.9	V
	25	8.6	L
	26	8.7	Ly
	27	8.7	Ma
7	2	8.7	Ba

184243
RW Lyrae

6	12	13.0	B
	19	13.5	E
	25	13.0	B
	25	13.4	E
	29	13.4	E

184205
R Scuti

4	26	5.3	L
	28	5.1	L

R Scuti

Mo.	Day	Est.	Obs.
5	3	5.0	L
	6	5.2	L
	12	5.1	L
	17	5.9	M
	22	5.2	L
	23	5.6	Ba
	25	5.5	G
	26	5.6	Ba
	29	5.5	L
	31	5.6	Ba
6	10	5.7	G
	11	5.6	Hu
	11	5.1	L
	11	5.7	Ba
	13	5.7	Ba
	15	5.6	Ba
	15	5.6	Ly
	16	5.4	G
	16	5.3	L
	16	5.6	Ba
	17	5.2	L
	18	5.6	Ly
	18	5.2	L
	20	5.3	G
	20	5.5	Ba
	20	5.8	Ly
	21	5.3	G
	22	5.2	L
	23	5.8	Ly
	24	6.0	Bu
	24	5.2	L
	25	5.6	O
	25	5.6	G
	26	5.6	O
	27	5.5	Ma
	28	5.7	Ly
	30	5.5	Ba
7	2	5.6	Ba
	8	5.6	O

190108
R Aquilae

4	28	10.4	L
5	2	10.5	L
	6	10.8	L
	22	11.1	L
	31	10.8	Ba
6	2	11.2	L
	12	11.0	G
	13	11.4	L
	17	11.4	O
	17	11.4	L
	22	11.4	L
	25	11.3	L

190529
V Lyrae

5	18	11.5	Ba
	31	11.4	Ba
6	15	11.9	Ba

190967
U Draconis

6	25	10.6	Hu

190926
X Lyrae

5	16	9.3	Ma
	18	9.0	Ba
	19	9.0	M
	30	9.0	Ma
	31	9.0	Ba
6	12	9.1	Ma
	16	9.3	G
	16	9.1	Ba
	27	9.2	Ma
7	2	8.9	Ba

191033
RY Sagittarii

6	12	7.5	H
	21	7.6	H

191019
R Sagittarii

4	26	8.3	L
5	3	7.9	L
	6	7.9	L
	22	7.6	L
6	2	7.9	L
	13	8.1	L
	17	8.2	L
	22	8.1	L
	25	8.3	L

191350
TZ Cygni

4	29	10.9	L
5	21	11.0	L
6	13	11.2	L
	18	11.2	L
	24	11.2	L

191637
U Lyrae

5	18	10.4	Ba
	31	10.5	Ba
6	15	10.7	Ba
	16	10.5	G
7	2	11.2	Ba

192928
TY Cygni

5	4	10.3	V
	18	9.6	Ba
	31	9.5	Ba
6	16	9.5	Ba
7	2	10.5	Ba

193311
RT Aquilae

4	30	12.0	L
5	31	13.0	Ba
6	16	11.5	Ba
	16	11.6	L
	18	11.4	L
	22	11.0	L
	25	10.5	L
	26	10.7	O
7	2	9.0	Ba

193449
R Cygni

Mo.	Day	Est.	Obs.
4	28	7.2	L
5	3	7.2	L
	9	7.3	Bb
	11	8.5	M
	16	8.0	O
	16	7.5	Ma
	17	7.8	Ba
	18	7.5	Le
	18	8.6	M
	21	8.0	L
	23	8.0	O
	24	8.0	Ba
	25	8.4	G
	25	8.7	M
	26	9.1	S
	28	8.8	M
	29	8.0	O
	31	8.2	Ba
6	1	8.2	Le
	1	8.6	Ma
	2	8.6	G
	9	8.6	L
	9	8.9	Ma
	10	8.6	G
	11	8.6	Ba
	13	9.7	Bl
	13	9.6	S
	14	8.8	O
	15	9.0	M
	16	9.0	L
	17	8.6	Le
	17	9.6	Bl
	18	9.1	O
	18	9.1	M
	19	9.2	St
	20	8.9	G
	22	9.0	O
	24	9.3	L
	25	9.0	O
	26	9.0	G
	27	9.6	Ma
	29	9.4	M
7	1	9.3	Le
	2	9.0	Ba

193509
RV Aquilae

6	26	8.8	O

193732
TT Cygni

4	29	8.0	L
5	4	8.1	L
	9	8.1	Bb
	16	8.2	Ly
	18	7.5	Ba
	19	8.8	M
	21	8.1	Ly
	22	8.1	L
	24	7.7	L
	28	8.2	Ly
	30	8.1	P
	31	7.3	Ba

VARIABLE STAR OBSERVATIONS May, June and July, 1914—Continued.

201521

TT Cygni				X Aquilae				SV Cygni				RT Capricorni				RW Cygni			
Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est	Obs	Mo.	Day	Est.	Obs.
6	2	7.9	G	6	2	9.5	L	6	25	8.3	G	5	3	7.7	L	6	6	9.1	Ly
	10	8.1	L		13	8.6	L		26	9.1	Ly		22	7.4	L		9	9.0	Ly
	13	8.3	Bl		16	8.7	Ba		27	9.2	Ma	6	2	7.4	L		11	9.0	P
	16	7.9	L		17	9.0	L		29	9.4	Bl		16	7.8	L		12	9.3	Ma
	16	8.0	Ly		20	8.6	O		29	9.0	E		19	7.8	L		14	9.0	O
	17	7.9	G		22	8.5	L	7	1	8.1	Le		25	7.8	L		15	9.1	M
	18	7.9	Hu		22	8.7	O										16	9.3	Ly
	22	7.3	L		25	8.5	O		200715a				201647				17	9.1	G
	24	7.3	L		25	8.4	Hu		S Aquilae				U Cygni				17	8.8	O
	26	8.4	Ly		26	8.7	G	5	18	9.1	Ba	4	28	10.2	L		18	9.0	M
	29	8.1	Bl						19	9.2	P	5	3	10.0	L		18	9.1	Ly
					194632				30	9.3	P		9	8.4	M		21	8.8	G
					χ Cygni			6	11	9.6	P		9	8.6	Bb		25	8.9	G
	194048			5	9	12.2	Bb		15	9.8	M		18	7.7	Ba		25	8.8	O
	RT Cygni				23	12.5	Bb		16	9.6	Sp		18	8.3	M		27	9.3	Ma
4	28	8.7	L	6	9	10.8	H		18	9.5	Sp		20	8.6	Ly		28	8.8	G
5	3	8.8	L		18	11.1	Hu		29	10.6	M		21	9.6	L		29	9.2	Bl
	9	8.8	M		29	13.2	E						23	7.8	O				
	9	8.7	Bb		195849				200715b				25	7.9	G		202946		
	11	9.1	M		Z Cygni				RW Aquilae				27	8.8	S		SZ Cygni		
	12	9.3	L	6	16	10.8	G	5	7	9.2	M		28	8.4	Ly	5	2	9.6	Bb
	16	9.1	O		29	9.7	M		18	9.0	Ba		31	7.8	Ba		9	9.2	Bb
	17	9.2	Ba						19	9.6	P	6	2	7.8	G		9	9.5	M
	18	9.2	M		200212				24	9.5	M		8	7.7	G		11	9.2	M
	18	9.3	Le		SY Aquilae				30	9.5	P		13	8.3	L		15	9.2	Ly
	21	9.4	M	6	2	10.5	L	6	11	9.2	P		14	7.6	O		17	9.3	Ba
	21	9.9	L		13	11.3	L		16	9.4	Sp		15	7.5	G		18	9.6	Ba
	23	9.6	O		17	11.2	L		18	9.7	Sp		15	8.9	R		18	9.7	M
	23	9.4	H		20	11.0	B		29	9.6	M		15	7.6	M		19	9.6	M
	24	9.9	L		20	11.1	O						16	8.1	Ly		20	9.8	Le
	24	9.9	Ba		22	11.8	L		200938				16	7.8	S		20	9.4	Ly
	25	9.5	M		25	11.9	L		RS Cygni				16	8.8	R		21	9.6	M
	25	9.3	G		25	11.1	B	4	29	8.6	L		19	7.9	Bl		22	9.7	Le
	28	9.6	M					5	4	8.5	L		20	9.0	R		23	9.6	Ly
	29	10.5	O		200647				9	8.3	Bb		20	7.6	P		23	9.3	Ba
	29	10.2	L		SV Cygni				18	7.8	Ba		20	7.5	G		24	9.1	M
	31	9.8	M	4	29	9.5	L		19	8.3	P		21	8.9	R		24	9.5	Le
	31	9.9	Ba	5	4	9.5	L		20	7.8	Le		22	8.2	L		25	8.9	Ly
6	1	10.2	Le		9	9.1	Bb		20	8.5	Ly		22	7.6	O		25	9.5	Le
	2	9.5	G		15	9.1	Bb		21	8.8	L		23	8.8	R		26	8.7	Ba
	10	10.4	G		16	9.4	Ma		24	8.8	L		25	7.4	G		26	8.7	Ly
	11	11.0	Ba		18	8.1	Ba		28	8.8	Ly		26	7.5	O		26	9.2	Le
	13	11.6	Br		18	9.0	M		30	8.4	P		26	8.0	Ly		28	8.6	Ly
	15	10.0	M		18	8.8	Le	6	2	8.1	G		29	7.9	Ly		28	9.6	M
	16	11.6	Ba		20	9.1	Ly		3	8.3	Le						29	9.2	Le
	17	10.0	Bl		23	9.2	Ly		8	7.9	G		202539				30	9.0	Ly
	18	11.7	Hu		23	9.4	Bb		9	8.8	Ly		RW Cygni				30	9.4	P
	18	10.2	M		24	9.6	L		11	8.6	P	5	2	9.1	Bb		31	9.6	M
	19	11.0	Le		25	9.0	G		15	8.4	L		9	9.2	M		31	8.9	Ba
	24	12.0	H		28	9.0	Ly		16	8.9	Ly		9	9.2	Bb	6	1	9.5	Le
	29	11.4	M		30	9.2	Ma		17	7.9	G		14	9.1	Ly		2	9.6	Le
7	2	11.9	Ba		30	9.0	P		21	8.8	L		15	9.6	Bb		3	9.7	Le
					31	8.2	Ba		24	8.8	L		18	8.7	Ba		7	9.6	Le
				6	3	8.9	Le		25	7.5	G		18	9.5	M		9	9.0	Ly
	194348				8	8.4	G		26	8.7	Ly		21	9.1	M		10	9.2	Le
	TU Cygni				11	9.1	P	7	1	8.0	Le		21	9.1	Ly		11	8.7	Ba
6	18	12.1	Hu		12	9.2	Ma						23	9.2	M		11	9.3	P
					13	9.5	L		200916				23	9.3	Ly		12	9.0	Le
	194604				14	9.0	M		S Sagittae				25	9.0	G		13	9.0	Ba
	X Aquilae				16	9.1	Ly	6	16	8.6	Sp		28	9.4	Ly		13	10.4	Br
4	30	10.5	L		18	8.9	Hu		18	8.6	Sp		30	9.3	P		14	9.4	Le
5	4	10.5	V		20	9.2	P						30	9.4	O		14	9.6	M
	21	10.0	L		22	9.3	L		201008				30	9.1	Ly		15	9.4	Le
	31	9.3	Ba		23	9.1	B		R Delphini				31	8.5	Ba				
								5	31	12.6	Ba								

VARIABLE STAR OBSERVATIONS May, June and July 1914.—Continued.

SZ Cygni

Mo.	Day	Est.	Obs.
6	15	9.5	Br
	15	9.4	Ba
	16	9.5	Le
	16	9.5	Ly
	17	9.6	Le
	17	10.0	M
	17	9.5	Ly
	18	9.7	Le
	18	9.7	Hu
	18	9.7	Ly
	18	10.2	M
	19	9.6	Le
	20	10.0	Ba
	20	9.9	Ly
	20	9.6	Le
	21	9.6	R
	23	9.5	Le
	23	9.4	R
	23	9.5	Ly
	26	8.9	Ly
	26	9.1	Le
	27	9.0	Le
	28	9.1	Ly
	29	9.2	Le
	29	9.5	M
	29	9.4	Bl
	29	9.2	Ly
	30	9.1	Ba
7	1	9.4	Le
	2	9.5	Le
	2	9.9	Ba
	3	9.5	Le
	4	9.7	Le
	5	9.8	Le
	6	9.8	Le

202954
ST Cygni

Mo.	Day	Est.	Obs.
6	18	11.7	Hu

203847
V Cygni

Mo.	Day	Est.	Obs.
5	19	9.7	M
	21	9.6	M

205923
R Vulpeculae

Mo.	Day	Est.	Obs.
5	3	11.4	L
	21	9.5	L
	24	9.1	L
6	11	7.6	L
	11	8.1	P
	17	7.7	L
	22	7.9	L
	25	8.2	L
	26	8.1	Hu

210868
T Cephei

Mo.	Day	Est.	Obs.
4	30	10.0	L
5	6	10.0	L
	19	9.5	P
	29	9.6	Ly
	21	9.7	Ly
	21	9.6	L
	22	9.4	Le
	25	9.5	M
	26	10.3	Ba
	27	9.4	S
	29	9.4	L
	30	9.4	P
6	3	9.0	Le
	4	9.6	Ly
	11	8.5	Ba
	11	9.4	P
	11	9.0	L
	13	9.0	S
	16	9.5	Ly
	17	8.8	O
	17	8.9	L
	19	8.2	St
	20	9.3	P
	22	8.7	L
	22	8.2	O
	23	8.9	Ly
	25	8.7	G
	25	8.6	L
	26	8.8	Ly
	27	8.2	Ma
7	1	7.4	Le

211614
X Pegasi

Mo.	Day	Est.	Obs.
5	31	11.0	Ba

213044
W Cygni

Mo.	Day	Est.	Obs.
4	28	5.4	L
	29	5.7	L
5	2	5.6	L
	6	5.6	L
	12	5.7	L
	21	5.8	L
	22	5.7	Le
	24	5.8	L
6	7	6.0	Le
	10	6.2	L
	11	5.5	G
	13	6.1	L
	16	6.0	L
	18	6.0	L
	21	6.0	L
	24	6.1	L
	25	5.7	G
7	1	5.8	Le

213337
UU Cygni

Mo.	Day	Est.	Obs.
4	29	8.4	L
5	3	8.3	L
	12	8.3	L
6	13	8.3	L
	19	8.3	L

213553
RU Cygni

Mo.	Day	Est.	Obs.
6	10	8.9	G
	11	8.8	P
	17	8.7	G
	21	8.7	G
	22	8.6	Sp
	23	8.9	Ly
	29	8.8	Ly

213678
S Cephei

Mo.	Day	Est.	Obs.
5	26	9.0	Ba
6	11	10.2	S
	15	9.6	Ba

213843
RU Cygni

Mo.	Day	Est.	Obs.
5	19	8.7	P
	19	9.3	M

213753
SS Cygni

Mo.	Day	Est.	Obs.
4	26	12.0	L
	28	11.8	L
	29	11.6	L
	30	8.3	L
5	2	8.2	Ba
	2	8.0	L
	3	8.0	L
	4	8.0	L
	6	8.2	L
	9	8.6	Bb
	9	8.4	M
	11	8.3	L
	11	8.4	M
	12	8.4	L
	14	9.9	Ba
	17	10.6	Ba
	18	10.6	M
	18	11.6	Ba
	19	11.0	M
	21	12.0	L
	22	11.4	Le
	23	11.7	Bb
	24	11.7	M
	24	11.6	Ba
	24	11.8	L
	25	11.4	Le
	26	11.9	Ba
	30	11.3	Y
	31	12.0	M
	31	11.6	Ba
6	2	11.7	Y
	10	11.8	L

SS Cygni

Mo.	Day	Est.	Obs.
6	11	11.6	Ba
	11	11.8	G
	12	11.9	Le
	13	11.8	L
	14	11.8	Le
	15	11.6	Ba
	15	11.7	E
	16	11.9	Le
	16	11.8	L
	16	11.7	Ba
	17	11.8	L
	17	12.0	M
	17	11.8	Le
	18	12.0	M
	18	11.9	Le
	18	11.8	L
	19	11.9	Le
	19	11.8	L
	20	11.6	Ba
	20	11.8	Le
	20	11.8	Ly
	21	11.9	L
	21	11.9	G
	22	11.9	L
	23	11.8	L
	23	11.8	Le
	24	11.8	L
	25	11.8	L
	25	11.5	G
	25	11.7	E
	26	11.9	Hu
	26	11.7	Ly
	26	11.6	Le
	27	11.3	Le
	28	11.7	Ly
	29	11.3	Le
	29	11.6	Ba
	29	11.6	E
	30	11.6	Ba
7	1	11.0	M
	1	11.3	Le
	2	9.7	Ba
	2	9.1	Ly
	3	8.3	Le
	4	8.3	Le
	5	8.5	Le
	6	8.7	Le
	8	8.3	O

213937
RV Cygni

Mo.	Day	Est.	Obs.
4	30	7.2	L
5	4	7.9	L
	9	8.1	Bb
	12	8.2	L
	19	7.6	P
	19	8.1	M
	22	7.9	M
	22	7.6	Le
	23	9.2	Bb

RV Cygni

Mo.	Day	Est.	Obs.
5	24	7.9	M
	25	7.6	G
	25	8.0	Ly
	26	7.6	L
	28	8.1	Ly
	30	7.4	P
	30	8.0	Ly
	31	8.0	M
6	7	6.9	Le
	10	7.3	G
	11	7.5	P
	12	7.5	Ma
	13	8.1	L
	16	7.9	Ly
	16	8.1	M
	17	7.8	Sp
	18	7.6	Sp
	18	7.0	L
	20	6.9	Ba
	21	7.2	G
	22	7.5	Sp
	24	7.2	L
	26	7.2	Le
	26	7.9	Ly
	27	7.2	Le
	27	8.2	Ma
	29	7.2	Le
	29	8.5	Bl
7	1	7.2	Le

214024
RR Pegasi

Mo.	Day	Est.	Obs.
5	31	12.4	Ba

230759
V Cassiop.

Mo.	Day	Est.	Obs.
5	19	9.9	P
	30	9.9	P
	31	10.3	Ba
6	11	9.8	P
	11	9.5	Ba
	20	8.9	Ba
	29	9.1	E
	30	8.8	Ba

231508
S Pegasi

Mo.	Day	Est.	Obs.
6	29	9.9	E

233335
ST Androm.

Mo.	Day	Est.	Obs.
5	31	9.5	Ba

235182
V Cephei

Mo.	Day	Est.	Obs.
5	12	6.5	C
	17	6.5	C
	19	6.5	C

235350
R Cassiop

Mo.	Day	Est.	Obs.
5	9	11.3	Bb

May-June No. of observations, 1296; No. of stars observed, 146; No. of observers, 22.
June-July No. of observations, 1328; No. of stars observed, 131; No. of observers, 23.

The following calculated dates of maxima by Dr. Hartwig are of interest in comparing the observations on the given dates:

004132	RW Andromedae	May 27
004958	W Cassiopeiae	" 2
054974	V Camelop.	June 8
064030	X Geminorum	May 10
074323	T "	" 28
095421	V Leonis	June 4
103769	R Urs. Maj.	May 4
115919	R Comae	June 4
120012	SU Virginis	" 24
123160	T Urs. Maj.	May 16
122803	Y Virginis	" 5
123459	RS Urs. Maj.	June 12
132422	R Hydrae	" 4
142539	V Bootis	May 8
154615	R Serpentis	" 10
162807	SS Herculis	" 23
165631	RV Herculis	" 17
184243	RW Lyrae	" 26
191019	R Sagittarii	" 11
200812	RU Aquilae	" 25
205923	R Vulpeculae	" 31
225120	S Aquarii	" 1

The following members contributed to this report: Messrs. Baldwin, Bancroft, Bouton, Bruseth, Burbeck, Craig, Eaton, Gray, Hunter, Huntington, Jacobs, Lacchini, Leonard, Lindsley, Mach, McAteer, Olcott, Putnam, Richter, Spinney, Stepka, Vrooman, Winterbottom, Miss Swartz, Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Secretary.

Norwich, Ct. July 10, 1914.

GENERAL NOTES.

The next number of POPULAR ASTRONOMY, the October issue, will appear about September 25.

The minister of finance in Russia has made a special ruling in regard to the transportation of instruments into Russia for the purpose of observing the total eclipse of August 21 next. All such equipment is to be admitted free of duty on the condition that the parties upon leaving shall also take all equipment with them. Further the minister of finance assures all visiting parties of his willingness to coöperate in any way possible.

Miss Susan Rose Benedict, Ph. D., (Michigan) has been made associate professor of mathematics at Smith College. (*Science* July 3, 1914.)

The Astronomer Royal, Mr. Frank Watson Dyson, has been elected Halley lecturer at the University of Oxford for next year. (*Science*, June 12, 1914.)

Professor L. E. Dickson, of the University of Chicago, will be visiting professor of mathematics in the University of California from August to December, 1914. (*Science*, June 26, 1914.)

A Martian Kellog fellowship in the University of California has been awarded to Mr. C. E. Adams, government astronomer of New Zealand, who will carry on research work at the Lick Observatory. (*Science* July 3, 1914.)

A Fine Collection of Meteorites has been acquired by the American Museum of Natural History, in New York, through the generosity of Mr. J. P. Morgan. This comprises the entire stock of meteorites which belonged to the unique establishment in Washington known as "Howell's Microcosm" at the time of Mr. Howell's death, and includes representatives of 54 falls, weighing in the aggregate about 220 pounds. (*Scientific Am.* June 6, 1914.)

Temperatures of the Stars.—During two years Rosenberg has studied photographically the spectra of the seventy most brilliant stars in the northern hemisphere, from the first to the third order of magnitude. By a comparison of their spectra it is possible to deduce their temperatures. The results obtained agree well with those of Wilsing and Scheiner; stars of the helium type are the hottest, and the red stars are the coolest. As a specimen the following temperatures are quoted: Sirius, 27,000 degrees; Vega, 22,000 degrees; Algol, 12,000 degrees; Arcturus, 3,000 degrees; Aldebaran, 2,000 degrees. (*Scientific Am.* June 6, 1914.)

Note:—The temperature of the sun, which belongs to the same class of objects as the stars mentioned, is thought to be about 10,000 degrees.

The Astronomical and Astrophysical Society of America.—The seventeenth meeting of the Astronomical and Astrophysical Society of America will be held at the Northwestern University, Evanston, Illinois, on August 25 to 28, 1914. These meetings will be held in part in the Dearborn Observatory of which the secretary of the society, Professor Phillip Fox, is director. Sessions for the reading of papers are planned for each of the days. There is also to be a reception given to the visitors on Tuesday evening, and an excursion on Thursday afternoon and evening. At the close of the meeting on Friday, those in attendance are invited to visit the Yerkes Observatory at Williams Bay, Wis., about seventy miles from Chicago. Because of the many attractive local features this will doubtless be an exceedingly interesting meeting.

A New Observatory.—Mr. F. E. Seagrave is just completing a new observatory and expects to be using it soon. Concerning the location and equipment of it, Mr. Seagrave writes as follows:

It is located about ten miles west of Providence, and about two miles north of the village of North Situate. Its position is altitude = 342 feet, longitude 71° 35′ 48″ west, latitude 41° 50′ 48″ north. The brick tower and revolving dome for the 8½-inch refractor is 16½ feet in diameter inside measure. The floor of the observing room is ten feet above the ground floor. To the east of the dome is a small transit room and adjoining that is a room about 14x14 feet to be used as a computing room and for meteorological instruments.

The 8½-inch telescope was dismounted and removed from the old observatory in Providence last January, and was taken to the Clark factory in Cambridgeport to be thoroughly overhauled. It will be remounted in a new observatory about August 25. Many improvements have been made in connection with the mountings of the telescope. Besides the 8½-inch telescopes are many smaller instruments. A 3-inch refractor, a 10 prism solar spectroscope by Browning, a 2-prism direc-(stellar) vision spectroscope by Browning. Besides the regular filar micrometer that belongs to the 8½-inch telescope there is a fine double image micrometer by Browning. A very valuable sidereal (Kullberg 1178) chronometer also belongs to the equipment.

The new observatory is situated on an elevation, and commands a splendid view in every direction. It is far away from the smoke, dust, haze and electric lights of a big city and I am sure that the seeing will be far better there than at most New England stations.

F. E. SEAGRAVE.

Boston, Mass. July 12, 1814.